

**Oldman River Dam
Wildlife Habitat Mitigation Program**

**Assessment of Planted Tree and Shrub Seedlings
1994 - 1995**

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EXECUTIVE SUMMARY

A Wildlife Habitat Mitigation Program was developed and implemented between 1987 and 1993 to minimize the impacts of habitat loss associated with flooding of the Oldman River Dam reservoir. The program included a variety of mitigation approaches including habitat protection, habitat enhancement and habitat creation. As part of this program, approximately a quarter million tree and shrub seedlings and rooted cuttings were planted to enhance areas of existing wildlife habitat and to create new cover and food/cover habitat.

An assessment of selected mitigation planting projects was undertaken in 1994 and 1995. Survival and growth of planted seedlings as well as damage caused by wildlife, disease, insects, and other factors were assessed.

Fourteen locations were chosen to represent the variety of mitigation planting projects located around the perimeter of the reservoir. At each site the number of living and dead seedlings were counted in sample plots to assess survival. Heights of all living sampled plants were measured and plants were examined for evidence of past and recent deer browsing, insect, disease, and other damage. Weed problems at the site, and general competing site vegetation were also noted. Two additional sites with wildlife exclosures around a portion of the plantings were also assessed. Plant height and width were compared inside and outside the exclosures.

It was not possible to statistically generalize the conclusions to the entire population of planted trees and shrubs around the reservoir. Nor was it possible to statistically determine causal relationships between the survival and growth with the numerous variables involved. Instead, general trends in the data were noted and any likely causative factors were discussed with further scientific testing recommended.

Average survival of planted seedlings was 45% for all species combined. Aspen, choke cherry and saskatoon had the highest survival rate (48% for each species). Douglas fir and Northwest poplar showed the lowest survival rates of 13% and 17% respectively. The majority of plants showed no height increase, or a decrease in height from the time of planting. Choke cherry and saskatoon had the largest percentage of plants showing growth. Larger planting stock showed more growth than smaller stock of the same species.

Competing site vegetation and deer browsing damage were the two main factors affecting survival and growth in this study. Abiotic factors including climate and site conditions were also noted to be of importance. Damage caused by insects, disease, and small mammals did not appear to be significant. It is likely that much of the mortality and damage caused by competing vegetation, deer browsing, and insufficient moisture could have been avoided if the plantings at each site were more carefully monitored, and the necessary care and maintenance were provided to sites after planting.

The existing plantings currently require vegetation control and protection from browsing to ensure that they will survive and grow beyond the vulnerable seedling stage, and eventually provide the food and cover habitat that they were planted to replace.

If future plantings are required to fulfill habitat replacement goals, sufficient initial watering, timely weeding, and the application of deer repellents during seedling establishment should improve results.

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1 INTRODUCTION

The Oldman River Dam is located in southwestern Alberta 10 km northeast of Pincher Creek, a short distance east of the confluence of the Oldman, Crowsnest and Castle Rivers, (Figure 1). Construction on the dam began in 1986 and was completed in 1991. At full supply level, the reservoir covers an estimated area of 2,420 ha.

To minimize the impacts of habitat loss associated with flooding of the Oldman River Dam reservoir, a Wildlife Habitat Mitigation program was developed and implemented between 1987 and 1993. The program included a variety of mitigation approaches including habitat protection, habitat enhancement and habitat creation. As part of this program, approximately a quarter million tree and shrub seedlings and rooted cuttings were planted to enhance areas of existing wildlife habitat and to create new cover and food/cover habitat.

An assessment of selected mitigation planting projects was undertaken in 1994 and 1995. The main objectives of this survey were to assess the survival and growth of planted seedlings, and to assess damage to these plantings caused by competing vegetation, wildlife, disease, insects, and other factors.

1.1 Background

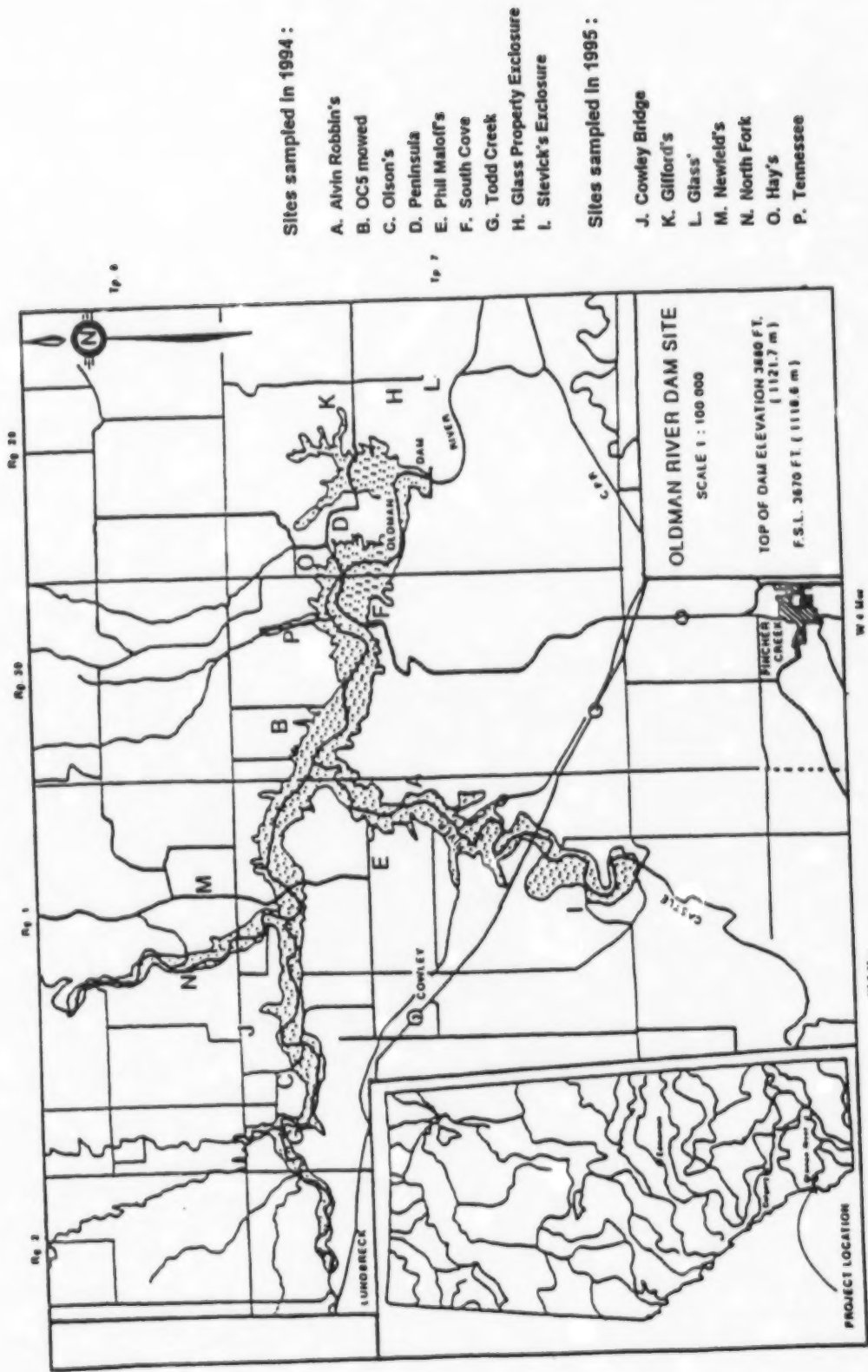
1.1.1 Biophysical setting

The Oldman River Dam area is located predominantly within the fescue grass ecoregion (Strong and Leggat 1992). This ecoregion lies west of the mixed grass ecoregion, in a band parallel to the eastern edge of the Rocky Mountains and foothills. The Cordilleran-based climate appears to be the main factor affecting vegetation of this area (Kerr et al. 1993). The climate is characterized by high annual and diurnal temperature ranges, and considerable irregularity in frost free periods and growing days. Total annual precipitation is estimated at 445 mm. Rainfall is most abundant during May and June, with drier conditions occurring in late summer. Winter precipitation is higher than in the mixed grass ecoregion, but snow depth and cover are similar due to the influence of frequent warm dry chinook winds from the west that greatly modify the winter temperatures (Kerr et al. 1993).

Soil development varies throughout the region due to the diversity of terrain, parent material and micro-climatic conditions. Soils are typically Orthic Black Chernozems that have developed on a variety of lacustrine, morainal, and glaciofluvial deposits (Hardy Associates 1986).

The dominant vegetation type of this ecoregion is grassland, characterized by fescue and oat grass in its natural state. Shrubs and trees occupy sheltered sites with suitable soil and moisture conditions, including north and east facing slopes of valleys and coulees, riparian areas, slough depressions, ridges and knolls (Hardy Associates 1986). Common species include shrubby cinquefoil, buckbrush, roses, aspen poplar, balsam poplar, saskatoon, choke cherry, and wolf willow, with Douglas fir, and Lodgepole or limber pine occasionally occurring at higher elevations (Looman 1969).

Figure 1. Location of study plots at the Oldman River Dam site.



Due to grazing, mowing, and cultivation, very little original fescue grassland remains. Wildlife habitat is largely fragmented, with the highest species diversity remaining in the riparian communities along drainage channels (Kerr et al. 1993). The riparian woodlands of the Oldman river are considered to be of particular significance in southern Alberta (Kerr et al. 1993). As a result of flooding the Oldman River reservoir, approximately 368 ha of cottonwoods, 61 ha of Douglas fir, and 86 ha of aspen, saskatoon, chokecherry and juniper were lost (Nilson, pers. comm. 1995).

1.1.2 The Wildlife Habitat Mitigation Program

To mitigate the effect of wildlife habitat loss resulting from the construction of the dam and the flooding of the reservoir, Alberta Environment¹ initiated a number of studies which lead to the formulation of an Environmental Mitigation/Opportunities Plan. The wildlife component of the Environmental Mitigation/Opportunities Plan began in 1985 and 1986 with a review of pertinent information, followed by various field surveys of wildlife. A vegetation survey identifying the major plant communities and listing the plant species present in the reservoir area was conducted in 1984 and 1985 (Hardy Associates 1986). This report also included a brief reclamation plan.

In 1987 The Delta Environmental Management Group Ltd. (the Delta Group) was retained by the Planning Division of Alberta Environment to prepare a strategy for wildlife habitat mitigation at the Oldman River Dam site. Opportunities for wildlife habitat mitigation in the vicinity of the reservoir were identified in 1988 (Green and Eccles 1988). In 1989, a mitigation strategy plan was prepared for Alberta Public Works Supply and Services (APWSS) that included an assessment of the amount of habitat lost to flooding, and outlined strategies for habitat mitigation in the reservoir area (Green and Eccles 1989). This was followed by an action plan developed by the Delta Group in cooperation with APWSS, that detailed the mitigation activities and projects to be implemented, outlined an implementation schedule, and included an evaluation and maintenance program for these habitat projects (Nilson and Green 1989). The resulting habitat mitigation program employed a combination of three major mitigation approaches: habitat protection, habitat enhancement, and new habitat creation, to minimize the impact of habitat lost due to the flooding of the reservoir area.

To protect the remaining tree and shrub based habitat, and to encourage natural shrub regeneration, a land base of approximately 2800 ha around the perimeter of the reservoir was acquired and fenced to control grazing. Enhancement measures included the placement of snow fencing along the perimeter fence and within various projects to increase soil moisture and encourage the recovery and encroachment of native trees and shrubs up the coulee slopes. Additional trees and shrubs were also planted on the leeward side of snow fences in each project and around existing wetlands to improve habitat quality. Check dams and riparian dams were built to create additional wetland habitat and to provide a source of irrigation water for upland habitat creation projects. These ponds permitted upland tree and shrub cover to be planted on exposed sites with poor soil moisture. Tree and shrub corridors were also planted on north facing hillsides to promote wildlife movement around the reservoir. Irrigation systems were installed in several of these sites to insure adequate soil moisture for seedling establishment.

¹ Responsibility for construction of the Oldman River Dam project was transferred from the Development and Operations Division of Alberta Environment to Alberta Public Works, Supply and Services in November, 1988.

Initial plantings in 1987 and 1988 consisted of commercially available cultivars such as caragana, Northwest poplar, and Colorado spruce. In 1989 the program began to use native species including: Douglas fir, aspen, willow, saskatoon, choke cherry, buckbrush, wild rose and limber pine. Hawthorn, skunkbrush, juniper and dogwood were also recommended but were not used in the plantings. Seeds were collected and plants were propagated from local stock within and around the reservoir area. Local seed collected from limber pine and aspen poplar was not viable for two years. Limber pine seed used came from about 100 km north west of the project area, whereas aspen seed came from approximately 400 km north of the project area (Nilson, pers. comm. 1995).

In 1989, the Delta Group estimated that a total of 97,758 trees and shrubs were required to complete the proposed projects and to fulfill the habitat requirements. In September, 1991, due to an underestimation in their 1989 figures, the Delta Group revised this number to 498,795, over five times the original amount (Appendix I). Because using native trees and shrubs required the pre-ordering of stock up to three years in advance, APWSS was unable to fully accommodate these changes, and only 254,000 plants were delivered before the completion of the tree planting program (Nilson, pers. comm. 1995).

Based on preliminary indications of substantial native shrub regeneration following a removal of grazing on the mitigation land base, the focus of the planting program was shifted in 1991 to concentrate on planting trees and shrubs that were not recovering substantially on their own, including aspen, poplar and Douglas fir, limber pine and sandbar willow (Nilson, pers. comm. 1995). The planting program ended in 1993, and the mitigation program was then placed under the jurisdiction of Alberta Environmental Protection.

1.1.3 Monitoring of habitat projects

Evaluation and monitoring of the habitat projects to ensure that adequate compensation for lost habitat was being provided was considered to be an integral component of the wildlife mitigation program (Nilson and Green 1989). The vegetation monitoring component of the suggested evaluation program included annual assessments of the survival of tree and shrub seedlings to provide information on their establishment and to highlight the need for supplemental or replacement plantings (Nilson and Green 1989). A very limited assessment of the shelterbelt and nursery plantings took place in 1989. At this time, there were only a few planting projects that consisted mostly of non-native species planted prior to the Delta Group's recommendations. The survey provided survival rates for caragana, Northwest poplar, Colorado spruce, blue spruce, and Douglas fir, based on ten samples from two sites (Smreciu 1990). Monitoring of plantings did not occur in 1990 or 1991, but it was suggested that it be continued in 1992 and every 2 to 3 years, for up to 10 years after planting (Smreciu and Hobden 1992). No site assessments were done until the spring of 1994 when this field survey was initiated to assess the state of the plantings and to identify any potential deficiencies or problems in need of correction.

At the commencement of this study in 1994, baseline information on the mitigation plantings (including planting site layouts, number and type of species planted at each site, site preparation and height at planting) was not available from APWSS. Therefore, seven locations were selected based on geographic location, apparent age of the plantings site and species present, to provide a representative sample of the various mitigation projects (Figure 1). Two additional sites with wildlife exclosures around a portion of the plantings were also assessed. In the winter of 94/95, APWSS provided data on each of the planting sites. Based on this information, seven more sites

were chosen for sampling in 1995 (Figure 1). This report will discuss the results of the 1994 and 1995 planting surveys.

1.2 Objectives of this survey

The main objectives of this survey were to assess the survival, height growth, and health of planted tree and shrub seedlings in selected habitat creation projects located throughout the mitigation land base of the Oldman River Dam reservoir. This assessment was undertaken to identify any potential deficiencies or problems with these planting projects, and to indicate where corrective measures may be necessary.

2 METHODS

Fourteen planting projects located around the perimeter of the reservoir were sampled (Figure 1). At each site, the number of living and dead seedlings were counted in sample plots to assess survival. Heights of all living sampled plants were measured and plants were examined for evidence of past and recent deer browsing, insect, disease, and other damage. Weed problems at the site, and general competing site vegetation were also noted. Two additional sites with wildlife exclosures around a portion of the plantings were also assessed. Plant height and width were compared inside and outside the exclosures.

2.1 Sampling

Sites were chosen in collaboration with J. Mahoney (Oldman River Dam project biologist) to represent the variety of planting projects present around the perimeter of the reservoir. Baseline information on each site was not available until the first year of the planting survey was complete. Each site differed in many ways including differences in planting layouts (number, shape, size and location of planting units), site preparation (or combinations of different site preparations), as well as in the amount, type, pattern, and spacing of species planted. As a result, it was not feasible to use one uniform sampling method and sample size at all sites. Samples within a planting site were chosen to represent the variations in planting unit size, shape, species composition and topography noted at the planting site.

In general, sites were sampled according to the following guidelines: (1) If planting units were of a manageable size and the unit was repeated throughout the site, entire units were chosen and counted to provide a rough estimate of the number and species planted at the site. (2) When planting units were very large, or boundaries between planting units were not distinct, a representative portion (or portions) of the unit was chosen, measured and counted. For example: (a) In large, irregularly shaped planting areas, a transect or a rectangular shaped plot within the area (at least 10% and up to 30% of the site) was measured and counted. (b) If the plantings ran in one long strip, a representative portion or portions of the strip were counted. (c) If the plantings ran in several strips, a number of the strips (or equal portions of several long strips) were chosen and counted.

Using a subjective, rather than random sampling method at each site made it impossible to statistically generalize the conclusions to the entire population of planted trees and shrubs around the reservoir. However, because a sizable portion of the projects were sampled (14 of 31), and

generally large samples were taken at each of these sites, it is likely that major trends noted may be of concern for all of the sites.

Because experimental plots (with defined treatments, controls and adequate replicates) were not initially established, it was impossible to statistically determine significant differences in survival, height growth or damage between the various species, sites or treatments, or determine causal relationships between the survival, height growth and damage and the numerous variables present at each site. Instead, general trends in the survival and height growth for each species were identified, and the major differences in outcomes noted for different treatments were discussed. Groups of sites showing very high or low survival or growth were investigated to identify any common factors that would require experimental testing to determine if there is a causal link between them.

2.2 Species included in the study

The species included in the samples were: aspen (*Populus tremuloides* Michx.), choke cherry (*Prunus virginiana* L.), Douglas fir (*Pseudotsuga menziesii* (Mirb.) Franco), saskatoon (*amelanchier alnifolia* Nutt.), Northwest poplar (*Populus deltoides* Marsh. x *P. balsamifera* L.), limber pine (*Pinus flexilis* James), and rose (*Rosa sp.*)². Common Caragana (*Caragana arborescens* Lam.), and willow (*Salix sp.*) were also measured in the enclosure assessments.

Factors including nursery source, seed source, initial plant height, and planting container size and/or type, varied both between and within the different species and different sites. This information is available for each site in the APWSS wildlife habitat mitigation program, final report field data sheets (APWSS 1994).

2.3 Survival

To assess survival, all living, dead, and empty planting spots included in the sample were counted. In a site with only one species present, the survival rate could then be calculated by dividing the number of living plants found by the total number of living, dead, and empty spots. In most cases however, planting samples contained several species with no discernible planting pattern. This made it impossible to assign the empty spots or badly decomposed dead plants to a specific species. In such cases, only the number of living plants counted could be treated with certainty, and the total number planted of each species present had to be obtained from the APWSS final report field data sheets (APWSS 1994). This information could be taken directly from the APWSS field data sheets only when the chosen sample unit was also a defined and numbered planting polygon, with the amount and type of species planted within it recorded for that site. In most cases however, the sampling unit contained only a portion of a defined polygon. As well, for some of the planting sites, information was not recorded for the individual polygons within the site, only a total number of each species planted at the site was given. In such cases, an expected planting ratio for each of the different species in the sample unit was calculated using the values given for each type of species in either the polygon containing the sample, or the entire site. This expected percentage was multiplied by the total number of planting spots counted at the site (all

² The exact species of rose planted is uncertain. In the planting data recorded in the APWSS field notes, only "rose" is listed. The name "Alberta rose" was recorded on the map of one sampled site (OC5 mowed), which would indicate that *Rosa acicularis* Lindl. was planted. In the 1995 draft copy of the final report on the mitigation projects, the name "wild rose" (which would be *Rosa woodsii* Lindl.) was used.

living plants, dead plants, and empty planting spots) to give the estimated number planted at the site. The actual number of living plants counted for that species was then divided by the estimated number planted to give the estimated survival for that species.

There are possible sources of error involved with this method that should be noted. For example, overestimation of the number of holes that initially contained seedlings at the site would mean the total number of planting spots counted at the site will be higher than what was actually planted. As a result, the survival rates calculated using this figure would be underestimated. Conversely, in overgrown areas with very few living plants to indicate spacing and no site preparation to indicate planting spots, the total number of planting spots counted at the site may be less than the actual planted amount. The survival rate calculated using this figure would then be overestimated. In all cases, sites were very carefully examined to specifically avoid this problem. As a result, there should be very few cases where overestimation or underestimation of the total amount planted in an area is of significance.

To use the planting ratios obtained from the APWSS field data sheets to estimate the amount of each species planted in the sample, it was assumed that the sample that it is applied to contains the same ratio. The planting patterns that were used were not specifically recorded in the field data sheets. Although it appeared that the species in mixed species sites were planted randomly (hence allowing the sample to contain the same ratio of plants as listed in the overall polygon or site), we can not be certain that this is always the case. In at least one site (Cowley Bridge), it was strongly suspected that the actual amount of each species planted in the sample area did not correspond with the estimated amount calculated using the full site planting ratio. This raises the possibility of a clumped or other non-random type of distribution at the site. This site was excluded from the survival calculations.

The figures provided in the APWSS data sheets represent the "as planted" data, and are the only available source of information for the plantings. However, in several of the sites sampled, discrepancies were noted between this data and what was found in the field. These included differences in size and shape of polygons as recorded in the field notes compared to what was seen, large differences between the total number of plants recorded and the actual number counted in particular polygons, and unrecorded changes in species composition at a site, such as an additional planted species being present, or original plantings being overplanted with a new species.

When there were differences between the estimated number (based on total number counted in the site) for a species and that recorded in the APWSS field data notes, survival was calculated and presented based on both figures. The results based on the estimated number were usually considered more accurate for the sample, and survival results based on these were subsequently used in the discussion.

These observed and suspected discrepancies restricted the data that could be used to calculate survival, and reduced confidence in the values that were obtained. The importance of keeping detailed and accurate records of baseline data on the type and number of each species planted, planting patterns, spacing, and any changes made in the field, cannot be stressed enough. In future plantings, where eventual evaluation and monitoring are required, these problems can be avoided and more valid results can be obtained by taking the time to set up permanent experimental monitoring plots using appropriate experimental design.

2.4 Height growth

Each seedling in the sample was measured up to the tallest living portion of the plant and recorded in the appropriate height class. The height classes used in 1994 and 1995 are shown in Table 1. Height classes in both 1994 and 1995 range from 0 cm to 100 + cm. In 1995, after receiving information on initial planting heights, and after noting that plants were generally much shorter than initially expected, the smaller classes (10-25), (25-50) were expanded to (10-20), (20-30), (30-40) and (40-50) to provide more useful data. Initial planted heights were not known until after the 1994 sampling was complete. At that time it was found that some of the smaller planting sizes, (i.e. 15 cm), were recorded in a comparatively broad height class of 10-25. In these cases it could not be determined whether plants stayed the same height, or increased or decreased by up to 10 cm. However, these are small changes and general trends still stand out.

Table 1. Height classes used in 1994 and 1995

Date	Height Class (cm)							
1994	0 - 10	10 - 25	25 - 50			50 - 75	75 - 100	100 +
1995	0 - 10	10 - 20	20 - 30	30 - 40	40 - 50	50 - 75	75 - 100	100 +

Height information collected at sites that were later excluded from survival calculations was included in the height data analysis to provide a larger sample size. However, even when the same sites are included for the survival and the height data, the number of plants measured in the height distribution tables may differ slightly from the number of living plants used to calculate survival. When two of the same type of plants were found growing in one planting hole, both were sometimes measured for height and damage, while for survival calculations, only one was counted as the surviving plant, and the other was treated as a sucker growing from this plant. As well, in 1994 before planting information for the sites was known, when two possible planting species were found in a single planting hole, both were measured. At the time, it was not known whether two different seedlings may have been placed in a single hole, or whether one of the species was actually planted, and one had grown naturally in the planting hole. When the APWSS planting field notes arrived, the correct planted species were discerned and used for the survival calculations. However, for the two sites with planted rose (which often grew in planting holes with the planted seedlings), a few natural rose plants growing in the same holes as other planted species were measured for height and damage. Although they were not used in the survival calculations, the height measurements could not be separated out of the data, resulting in a slightly higher number of plants measured than used in calculating survival.

It should be kept in mind that initial measurements provided for the plantings in the APWSS final report field notes were general size categories (such as "6 inches", or "2-3 feet"), and these heights were not recorded until 1992. Initial planting heights are unknown for sites that were planted in 1987, 1989, and 1991. Most of the 1991 plantings sampled in this study were planted in the fall of that year, so the 1992 height estimates may still be quite close to the original planted height.

2.5 Competing vegetation

Notes were taken on general site vegetation. Major competing plants and the extent of their effect were recorded. In 1995, density distribution classes were recorded for the dominant species at each site, and notes were made as to whether they occurred in planting holes or on planting preparations.

2.6 Damage or injury

Although numerous environmental factors (and interactions between them) present at the different sites have contributed to survival and growth of planted materials, some of the more obvious factors, such as competing vegetation, animal browsing and insect or disease damage were noted for each plant.

In 1994, each plant was visually assessed for any apparent damage, and this was recorded under the appropriate damage category. The extent of the damage was not recorded for each plant. A plant with all leaves severely eaten by caterpillars was noted the same as a healthy plant with one bite on a single leaf. General comments recorded at each site regarding health of plants, and severity of damage were used to evaluate the extent of the damage. In 1995 the categories were changed slightly to reduce the collection of redundant or overly general information, and a section was added that included comments and rated specific types of damage as low, moderate and heavy, and overall health as good, fair and poor for each species (see Appendix II for 1994 and 1995 sample data sheets).

General trends noted provide some useful insights regarding these factors. However, the observations were subjective, and were based on a single observation for the particular date sampled. Damage data was recorded on different dates (day, month and year) for different sites and this probably influenced the information obtained.

2.7 Abiotic factors

Abiotic factors including climate and site conditions (soil, moisture, topography), that may have resulted in some of the damage noted, are discussed in this section.

3 RESULTS AND DISCUSSION

3.1 Results by species

The results of this study are grouped and described by species with reference to each specific sampling site. When site data is grouped (post hoc) in this way, some species such as aspen were adequately represented, while others including rose, Northwest poplar and limber pine were represented by very few sites and/or a small number of plants in the samples taken.

Average combined survival for the various species sampled in both 1994 and 1995 are presented in Table 2. Limber pine survival could not be calculated as a result of problems with the APWSS field notes for the sites sampled. Average survival was 45% for all species combined. The lowest survival was seen for Douglas fir and Northwest poplar (13% and 17% respectively). Aspen, choke cherry, and saskatoon had the same survival rate of 48%. Rose had the highest survival rate

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(159%), but this figure is suspect, due to the small sample size and suspected problems with the figures used to estimate the number planted in the sampled area.

Table 2. Survival of sampled tree and shrub plantings, 1994 and 1995 combined

Species	Survival (%)		Initial # of plants in sample	
	A	B	A	B
Aspen	48	42	3483	4065
Choke cherry	48	42	858	980
Douglas fir	13	13	438	453
Rose	159	89	37	66
Saskatoon	48	34	638	903
Northwest poplar	17	17	143	143
All species combined	45	38	5597	6610

A: Based on estimated amount planted in sample area. These figures are considered to be the more accurate of the two, and are used in the discussion.

B: Based on estimated amount and amount recorded in APWSS field notes where provided.

3.2 Aspen

3.2.1 Survival

Aspen survival rates for all sites sampled in 1994 and 1995 are presented in Table 3a. Survival of aspen based on an estimated 3483 seedlings planted at 10 different sites and counted 1 to 3 years after planting averaged 48%, and ranged from 4% to 85% (Table 3a).

Average survival in sites sampled one year after planting was 67%. Sites sampled after two and three years showed a rate of 55%, and 23% respectively (Table 3b).

Survival differed quite markedly between sites. Of the ten sites sampled, four sites (33% of the total number of aspen spots counted) appeared to be doing well with approximately 70% to 85% survival. The other six sites were less successful, with five sites ranging between 30% and 42% survival, and one with less than 5% surviving (Table 3a). It is likely that the high and low survival rates seen in the above mentioned groups are influenced in part by the number of years between planting and sampling. The group of sites showing the highest survival also had the largest proportion of planting spots sampled after one year. The sites with poorer survival had a larger proportion of their planting spots sampled after two or three years (Table 3b).

It is not uncommon to see a downward trend in survival of tree and shrub seedlings for up to four or five seasons before mortality levels off (Mckell and Van Epps 1980). However, because the results of this study are based on a single measurement from a number of samples and sites differing temporally and spatially, it can not be inferred that aspen survival is decreasing with time. Setting up permanent monitoring plots and doing yearly counts is recommended to determine the actual survival rate over time. If the low survival of plants sampled three years after planting is representative of a general trend and not simply the result of other variables, there is greater

urgency to determine the main causes of mortality, and to implement protective measures for both existing plants and supplemental plantings to increase their chances of survival.

Table 3a. Survival of Aspen for all sites sampled in 1994 and 1995

Site name	Site #	Weed control site prep.	Date planted	Date sampled	Total # of plants in sample		Survival (%)	
					A	B	A	B
Peninsula	1	WM	1992	1994	544	606	85	76
Olson's	2	WM	1993	1994	273	582	37	17
Phil Maleff's	3	WM	1993	1994	325	325	84	84
South Cove	4	F-sq	1993	1994	162	162	84	84
Todd Creek	5	F-sq	1993	1994	103	103	69	69
Gifford's	6	WM	1992	1995	370	507	30	22
Tennessee	7	WM	1992	1995	370	370	4	4
Newfield's	8	none	1992	1995	292	366	39	31
Cowley Bridge	9	WM	1993	1995	601	601	36	36
North Fork	10	WM	1993	1995	443	443	42	42
All sites with Aspen :					3483	4065	48	42

A : Based on estimated amount planted in sample area. These are the figures referred to in the report.

B : Based on estimated amount and amount recorded in APWSS field notes where provided.

WM : wood mulch; F-sq : fabric square; none : no site preparation

Table 3b. Survival of Aspen at sites sampled approximately 1, 2, and 3 years after planting

Time between planting and sampling	Site #'s	# Of sites in sample	Total # of plants in sample		Survival (%)	
			A	B	A	B
1 year	2,3,4,5	4	863	1172	67	50
2 years	1,9,10	3	1588	1650	55	53
3 years	6,7,8	3	1032	1243	23	19

A : Based on estimated amount planted in sample area. These are the figures referred to in the report.

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Time between planting and sampling	Site #'s	# Of sites in sample	Total # of plants in sample		Survival (%)	
			A	B	A	B
1 year	2,3,4,5	4	863	1172	67	50
2 years	1,9,10	3	1588	1650	55	53
3 years	6,7,8	3	1032	1243	23	19

A : Based on estimated amount planted in sample area. These are the figures referred to in the report.

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Table 3c. Survival of Aspen for sites sampled in 1994 and 1995, grouped by site preparation

Wood control site preparation	Site #s	# Of sites in sample	Total # of plants in sample		Survival (%)	
			A	B	A	B
Fabric squares	4,5	2	265	265	78	78
Wood mulch	1,2,3,6,7,9,10	7	2926	3434	47	40
No site preparation	8	1	292	366	39	31

A : Based on estimated amount planted in sample area. These are the figures referred to in the report.

B : Based on estimated amount and amount recorded in APWSS field notes where provided.

3.2.2 Height growth

Height growth of aspen is shown in Tables 4a, 4b, and 4c. Aspen sampled in the year after planting had a larger percentage of plants showing growth (17.2%) than those sampled two and three years after planting (less than 1% for both). For all years however, the majority of plants were still between 0 and 25 cm tall, with the highest percentage in the 10-(20)25 cm height class.

Very few of the sampled aspen showed any growth, and the heights of those that did were still below expected values. Although there is very little published information on growth rates of aspen seedlings, it is known that in the first 2-3 years, seedlings grow relatively slowly compared to suckers (Heeney et al. 1980). In general, seedlings usually grow less than 15 cm in the first season, adding another 15-30 cm in the second season, and under favorable conditions, reach a total height of 1.2 m by the end of the third growing season (Peterson and Peterson 1992).

The aspen seedlings planted were two years old and listed as being approximately 45 cm tall at the time of outplanting. This height corresponds with the average seedling growth after two seasons, as stated by Peterson and Peterson 1992. When measured during the growing season following planting, only 17.2% of the sampled aspen plants showed any growth, and of these, heights fell within the 50-75 cm class (Table 4a). The small amount of growth noted is not surprising for a number of reasons. To begin with, the recorded planting height of 45 cm is a generalization applied to all 2 year old aspen plants. Many of the actual heights may have been shorter. As well, plants were measured during the first growing season after planting, and would have likely shown more growth if all plants were measured in the fall, allowing a complete growing season after planting. Seedlings may also require time to recover from transplanting, and height growth may have been minimal during this first season as a result of energy being allocated to root growth.

Those sampled two and three years after planting did not fare any better, with less than one percent of the sampled aspen showing any growth. Again, these heights fell within the 50-75 cm height class (Tables 4b, 4c).

Based on a height growth curve presented in Peterson and Peterson (1992) the expected height after three, four and five years for aspen seedling growth can be calculated as 70, 140, and 250 cm respectively. Using this more conservative data, the few plants measured that showed growth in their third year were in a height class comparable to the expected height. For the even fewer aspen showing growth after their fourth and fifth year, height was considerably less than expected

(approximately 1/2 to 1/3 and 1/3 to 1/5 of the expected height for the fourth and fifth year respectively).

Assuming that they were initially at or close to 45 cm tall, the majority of the sampled aspen plants showed a decrease in height from that at planting. A decrease in height is possible because in this study, height was measured up to the tallest *living* portion of the plant. At nine out of the ten sites sampled, most of the living aspens appeared to be new sprouts (1-2 years growth maximum) growing from the sides, base, or roots of the dead main stem of the original planted aspen. Whether the dieback was caused by a single event occurring one or two years ago, (frost kill, or disease outbreak, etc.), or whether it is occurring each year as a result of other factors is unknown. In the latter case, plants may never grow past this vulnerable stage, and will remain in a stunted, shrubby state, or eventually die of the repeated, annual weakening. To determine whether dieback is chronic or occasional, permanent monitoring plots should be set up in selected plantings and assessed in early spring (before leaves), spring, summer and fall for growth, browse, insect damage and disease. Measurement of temperature and soil moisture at the sites should also be done to indicate whether climatic conditions are a factor. This procedure will give a more complete understanding of the actual growth occurring and the amount lost to these specific factors.

Table 4a. Height class distribution of living Aspen measured in the year after planting
(45 cm tall seedlings planted in 1993, measured in 1994)

Height class cm	Frequency distribution of Aspen (%)				Average
	Olsen's	Phil Maloff's	South Cove	Todd Creek	
0 - 10	10.3	7.7	10.3	11.6	9.3
10 - 25	52.6	51.3	36	14.5	43.5
25 - 50	32	27.8	26.5	43.5	38.1
50 - 75	5.2	13.2	26.5	29	16.9
75 - 100	0	0	0.7	1.4	0.3
100 +	0	0	0	0	0
# Of plants measured :	97	273	136	69	575

Dotted line is placed below the height class containing the approximate height at time of planting.

Table 3c. Survival of Aspen for sites sampled in 1994 and 1995, grouped by site preparation

Weed control site preparation	Site #'s	# Of sites in sample	Total # of plants in sample		Survival (%)	
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25 - 50	32	27.8	26.5	43.5	30.1
50 - 75	5.2	13.2	26.5	29	16.9
75 - 100	0	0	0.7	1.4	0.3
100 +	0	0	0	0	0
# Of plants measured :	97	173	136	69	575

Dotted line is placed below the height class containing the approximate height at time of planting.

Table 4b. Height class distribution of living Aspen measured two years after planting
(45 cm tall seedlings planted, Peninsula planted in 1992, measured in 1994; Cowley Bridge & North Fork planted in 1993, measured in 1995)

Height class cm	Frequency distribution of Aspen (%)			
	Peninsula	Cowley Bridge	North Fork	Average
0 - 10	18.7	37	23.4	24.3
10 - 25*	44.3	44.9	53.7	46.5
25 - 50**	35.7	18.1	22.9	28.5
50 - 75	1.3	0	0	0.7
75 - 100	0	0	0	0
100 +	0	0	0	0
# Of plants measured :	440	216	188	264

* includes 10-20 class for 1995 measurements

** includes combined classes of 20-30, 30-40, and 40-50 for 1995 measurements

Dotted line is placed below the height class containing the approximate height at time of planting.

Table 4c. Height class distribution of living Aspen measured three years after planting
(45 cm tall seedlings planted, all sites planted in 1992, measured in 1995)

Height class cm	Frequency distribution of Aspen (%)			
	Gifford's	Newfeld's	Tennessee	Average
0 - 10	7.3	9.7	12.5	8.8
10 - 20	48.6	62.8	28	53.8
20 - 30	32.1	27.4	37.5	38.3
30 - 40	9.2	0	18.8	5.5
40 - 50	0.9	0	6.3	0.8
50 - 75	1.8	0	0	0.8
75 - 100	0	0	0	0
100 +	0	0	0	0
# Of plants measured :	109	113	16	138

Dotted line is placed below the height class containing the estimated height at time of planting.

3.2.3 Competing vegetation

In this study, competing plants appeared to have a significant effect on aspen growth and/or survival. Herbaceous plants and sod forming grasses are considered to be the greatest hazard for both natural regeneration and plantations of aspen (Peterson and Peterson 1992).

In the group of sites showing the highest survival (69-84%), the majority of the sites had relatively short and/or sparse vegetation (two with low native vegetation, one with short sparse brome). Only one site had thick dense brome. In the remaining sites with relatively poor survival (4-42%), four

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10 - 25*	44.3	44.9	53.7	46.5
25 - 50**	35.7	18.1	22.9	28.8
50 - 75	1.3	0	0	0.7
75 - 100	0	0	0	0
100 +	0	0	0	0
# Of plants measured :	468	216	188	944

* includes 10-20 class for 1993 measurements

** includes combined classes of 20-30, 30-40, and 40-50 for 1993 measurements

Dotted line is placed below the height class containing the approximate height at time of planting.

Table 4c. Height class distribution of living Aspen measured three years after planting
(45 cm tall seedlings planted, all sites planted in 1992, measured in 1995)

Height class cm	Frequency distribution of Aspen (%)			Average
	Gilford's	Newfield's	Tennessee	
0 - 10	7.3	9.7	12.5	8.8
10 - 20	48.6	62.8	28	53.9
20 - 30	32.1	27.4	37.5	38.3
30 - 40	9.2	0	18.8	5.5
40 - 50	0.9	0	6.3	0.8
50 - 75	1.8	0	0	0.8
75 - 100	0	0	0	0
100 +	0	0	0	0
# Of plants measured :	109	113	16	238

Dotted line is placed below the height class containing the estimated height at time of planting.

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out of six sites were obscured by tall thick vegetation to the extent that the seedlings often had to be dug out from underneath the cover in order to be counted.

The vegetation at three of the sites with poor survival was dominated by brome, one site had tall dense native vegetation, and the remainder (two) had shorter native vegetation. The site with less than 5% survival was severely overgrown by tall, dense vegetation. The only aspens surviving at this site were found in a portion of one polygon that had shorter, sparser vegetation. This suggests that dense, thick site vegetation may play a role in reducing survival through overtopping and shading, and through root competition for moisture and nutrients. Aspen is considered to be shade intolerant, requiring relatively high light intensities for minimum photosynthesis. Full sunlight is required for optimum growth, especially at the sucker or seedling stage (Peterson and Peterson 1992).

In Alberta, aspen is noted as growing best on sites with good to moderate soil moisture (Steneker 1976). As a result, competition for light and moisture may have a large influence on aspen survival and growth. Steneker (1976) suggests that control of understory vegetation may do more to stimulate aspen growth than would an application of fertilizer. If larger, faster growing plants are planted and competing vegetation is controlled, aspen may be better able to establish and outgrow this initial competition. Once a deep root system is established, aspen should be better able to compete for water because understory species are not as deeply rooted and do not compete with aspen for moisture at soil depths below 1 m (Succoff 1982).

Different site preparations were used to reduce initial plant competition and allow the seedlings to establish. Survival results for sites grouped by site preparation are shown in Table 3c. In the case of the sampled aspens, plantings using fabric squares had a higher survival (78%), than those using wood mulch (47%), which had a slightly higher survival rate than the site with no site preparation (39%) (Table 3c). The significance of these differences cannot be proven statistically. Many other factors not held constant may have influenced these results, confounding any attempt at statistical analysis. For example, these observations may likely be influenced by time between planting and sampling.

Field observations indicate that fabric squares did appear to deter competing plants well, and wood mulch also worked well in some cases, but had the drawback of washing away on steeper slopes. The success of any of these treatments however, appeared to coincide with other factors, most notably, the height and density of the vegetation present at the site. With short or sparse site vegetation, any site preparation (including none at all) would likely work equally well, while with very dense, thick brome, all site preparations would be rendered less useful. For example, in densely vegetated sites, awnless brome and other weedy invaders were noted to grow in thick clumps out of the small slots in the fabric squares where the planted aspen had died out. The tall dense vegetation, especially awnless brome and alfalfa was able to overtop, shade out, and eventually mat over the plantings with dead vegetation in the autumn, even when fabric squares were used. In such cases, competition for moisture and nutrients with brome roots would also be high despite the presence of fabric squares on the surface.

3.2.4 Browsing damage

The majority of aspen seedlings (67%) showed some form of browsing damage, and 33% of all seedlings showed current year browsing damage (Table 5a). Browsing damage was generally higher in sites sampled in 1994 compared to those sampled in 1995 (Table 5b). This may be due

in part, to the fact that sites were sampled in the spring of 1995, and in the summer and fall of 1994, allowing more time for current year browsing to occur before sampling.

Deer browsing may be an important factor contributing to the height decrease, and mortality seen in this study. Mule deer were sighted feeding and resting in and around planting sites, and deer signs (deer pellets, bedding down sites) were often noted. Past and present year browsing damage was seen at all of the aspen sites (Table 5a).

Aspen are one of the trees most often ranked as heavily eaten (Kufeld et al. 1973). One study in southwestern Alberta, found that woody browse comprised 93.6% of the winter diet of deer, with 43% of this accounted for by a combination of aspen and saskatoon (Telfer 1994).

Deer browsing damage is a serious concern for establishing aspen hybrid plantations in the United States (Hansen et al. 1983). Frequent browsing of established seedlings and clipping of newly planted seedlings may result in decreased seedling vigor and increased mortality (Von Althen 1983). Physical injuries caused by browsing or trampling by deer may also make plants more susceptible to infection by pathogens (Peterson and Peterson 1991). If aspen plantations do not become well established in the first year, the slower growing trees may be browsed for several years and remain indefinitely in the shrub stage, in some cases resulting in the failure of the plantation (Netzer 1984).

Leaves up to a height of 1.52 m are within reaching distance of adult deer (up to 0.91 m for fawns)(Rogers and McRoberts 1992). Studies of hybrid poplar clones showed that a higher incidence of browsing occurred for trees under 1.3 m tall than for those greater than 1.6 m (Netzer 1984). Aspen plants measured in our study were all below one meter in height. If browsing pressure continues to be high, it is unlikely that the planted aspen will be able grow past this vulnerable stage.

With proper establishment and good initial height growth, aspen can grow above the reach of browsing deer in the first season, and well beyond in the second year (Netzer 1984). It is therefore desirable to maximize growth rates of aspen during the critical initial years. This may be achieved by planting taller, faster-growing plants and providing adequate protection from browsing. Aspen suckers suppressed by shading are more likely to be severely browsed than aspen growing rapidly in full sunlight (Gullion 1986). Reducing competing plants, and ensuring that irrigation systems are working adequately, should also increase rate of growth, reducing the number of years that it is necessary to actively maintain plantings to prevent deer browsing.

Although there is some evidence of small mammal use of planting areas such as droppings and indications of browsing on lower shoots and stem bark, small mammal damage did not appear to constitute a significant percentage of the damage sustained by the aspen plantings.

One study in northern Alberta showed that planted aspen suffered high rates of damage and mortality due to girdling damage caused by small mammals, particularly the common meadow vole (*Microtus pennsylvanicus*). Plots with higher ground cover provided suitable habitat for this rodent, and aspen survival was found to be negatively correlated to the amount of grass legume cover present during the fall assessment period (Fedkenheuer et al. 1980). Because the extent of small mammal damage and the possible contribution of this type of damage to initial dieback was not adequately assessed in this brief survey, future studies into small mammal populations, and their

effect on planted seedlings in this area would be needed to draw any firm conclusions on whether damage is significant, and population control is necessary.

If control is warranted, Green (1978) provides a review of the literature on techniques for controlling small mammal damage to plants. In this review, it was concluded that habitat manipulation, especially reduced ground cover was one of the best means of controlling rodent populations currently available (Green 1978). This step is already warranted to reduce shading damage and competition for soil moisture. Reduced ground cover would provide the additional benefit of reducing current levels of small mammal herbivory and may prevent future rodent population increases within the planting sites.

3.2.5 Insect and disease

The majority of aspen plants measured (78%) showed some damage in the insect/disease/small mammal category (Table 5a). There is a higher incidence of damage recorded in sites sampled in 1994 (94%) as compared to 1995 (39%) (Table 5b). This may be attributed to larger populations of insects or pathogens in 1994, but this may be confounded by a number of factors including individual site conditions, and differences in date of sampling. For example, some sites may have been sampled before defoliating insects hatched, while other sites were sampled after. The higher incidence of damage in both browsing categories in 1994 as compared to 1995, suggests there may have been a bias in sampling. More selective placement in categories may have occurred with increased experience in identification in the second season.

Although much is known about pathology and insect relationships in mature aspen stands, very little literature exists on the influence of pathogens or insects on young aspen stands. (Peterson and Peterson 1992). Some studies indicate that young aspen stands are susceptible to damage by numerous endemic insects and diseases (Perala 1984). This was found to be the case in the present survey. Some level of insect and disease damage was found in all aspen planting sites sampled, with the majority of plants having minor damage from a variety of sources such as leaf rolling caterpillars, leaf spot diseases, leaf rusts, powdery mildew, mite galls, caterpillar/beetle larvae damage, and ovipositing damage. Other studies on young sucker stands indicate that stems without at least one injury are rare (Millers 1972).

Due to the prevalence of insect and disease damage on the aspen plantings it is reasonable to assume that they contribute to the overall reduction in health and growth for this species. Based on field observations, current levels of damage appeared to be generally sustainable, with only a few cases appearing to have a large effect on a plant's overall survival and health. In one polygon sampled in 1994 (Olsons, V-1) all living and dead plants showed blackened, shriveled terminal leaves (possibly caused by a fungal blight). Aspen shoot blight, (*Venturia macularis* [Fr.] Mull. & Arx) is considered to be one of the most important diseases affecting sucker regeneration in young stands. In severe cases, 100% infection is not uncommon, and the damaged terminals may be more susceptible to other pathogens resulting in stagnation of the stand (Peterson and Peterson, 1992). Other common damage such as that caused by defoliating insects rarely results in mortality (Ives and Wong 1988), and may even stimulate growth in affected plants (Mattson and Addy 1975).

A more thorough study including the collection and identification of insects and pathogens on both the living as well as dead plants may lead to the discovery that these organisms play a larger role than initially indicated in this brief inventory.

Interactions between insects, disease and other factors may also be very important. Browsing damage and shading by competing plants may increase stress on planted materials allowing more successful pest invasions and thereby increasing damage (Peterson and Peterson 1992). Climatic conditions may also play a role. Dry weather can influence the occurrence of insects and disease, and during times of reduced soil moisture, pests damage can result in greater levels of mortality.

Table 5a. Incidence of damage to Aspen plants for all sites assessed in 1994 and 1995

Site name	Site #	Weed control site prep.	Year planted	Year sampled	# Of plants measured	% of total # of plants measured showing damage		
						Any browsing	Current year browsing	Insect/disease/ small mammal
Peninsula	1	WM	1992	1994	460	100	65	91
Olsen's	2	WM	1993	1994	97	91	16	92
Phil Maleff's	3	WM	1993	1994	273	34	33	99
South Cove	4	F-sq	1993	1994	136	42	8	95
Todd Creek	5	F-sq	1993	1994	69	99	14	100
Gifford's	6	WM	1992	1995	109	73	44	42
Tennessee	7	WM	1992	1995	16	69	13	50
Newfield's	8	none	1992	1995	113	88	19	45
Cowley Bridge	9	WM	1993	1995	216	45	4	N/A
North Fork	10	WM	1993	1995	188	39	22	32
All sites with Aspen :					1677	67	33	78

WM : wood mulch; F-sq : fabric square; none : no site preparation

N/A : not assessed at this site.

Table 5b. Incidence of damage for Aspen plants at sites sampled approximately 1, 2, and 3 years after planting, and for all plants measured in 1994 and 1995.

Plants measured:	Site #'s	# Of sites in sample	# Of plants measured*	% of total # of plants measured showing damage		
				Any browsing	Current year browsing	Insect/disease/ small mammal*
1 year after planting	2,3,4,5	4	575	53	22	97
2 years after planting	1,9,10	3	864	73	41	74
3 years after planting	6,7,8	3	238	80	30	44
In 1994	1,2,3,4,5	5	1035	74	41	94
In 1995	6,7,8,9,10	5	642	57	19	39

* Cowley Bridge (site # 9, 216 plants), was not included in calculating insect/disease/small mammal damage as this information was not recorded at this site.

3.2.6 Abiotic factors

Climate, terrain and soils were not specifically addressed in this study but their influence on seedling survival and growth suggests that further investigation of these factors be undertaken before any additional plantings are done.

In the fescue grass ecoregion, although shoots and seedlings of aspen appear to establish readily in sheltered locations, their survival rate is usually very low. Even in favorable situations, it is estimated that only about 1% of these shoots and seedlings survives to the age of 50 years (Looman 1969).

Drying chinook winds may take their toll on aspen seedlings. Wind exposure is known to limit aspen growth, and in the foothills of Alberta, chinook winds are known to damage aspen branches and buds (Peterson and Peterson 1992). Snow fencing placed at many of the planting sites to increase soil moisture may prevent some of the damage caused by these drying winds.

Spring frost can damage new leaves, and inhibit both leader and radial growth of aspen (Strain 1966). Frost can also cause cankers and dieback (Zalasky 1976). The leader dieback seen in many of the aspen sites may have been caused by this.

Soil moisture has been listed as the most important factor affecting growth of aspen (Fralish and Louks 1975). Although aspen sucker stands are able to tolerate drought through their connection to well established root systems (Perla and Russel 1983), drought is the most common cause of mortality in aspen seedlings (Peterson and Peterson 1992). Many of the aspen planting sites are located on the upper portions of slopes where only grassland vegetation previously existed. Aspen grows best in sites where the water table is between 1.0 and 2.5 m deep, especially in coarse and medium textured soils (Haeussler and Coates 1986). Inadequate moisture may have been one of the factors involved in the mortality and diebacks noted at many of the aspen sites if the water tables at these sites were not close enough to the surface for the aspen roots to reach. It is not known whether the snow fences present at most of the sites increased soil moisture to levels adequate for seedling survival. Soil moisture deficits could be reduced if the plantings were irrigated sufficiently during the critical establishment period to allow the roots to grow down to the water table. However, it is not known whether irrigation of planted seedlings was adequate, as actual site watering schedules, and records of weekly or bi-weekly soil moisture level monitoring (as recommended in the site maintenance schedules included in APWSS 1994) were not available.

In a modeling study estimating aspen site quality indexes for Wisconsin, multiple linear regression analysis indicated that aspen growth, expressed by site index, is highly dependent on the availability of water for growth (Fralish and Louks 1975). Available water, in turn, is dependent on: the water holding capacity of the top 30 cm of soil, the depth to the water table, and on the water usage as influenced by the exposure of the site (Fralish and Louks 1975). All of these factors should be carefully considered before a site is chosen for planting. If irrigation is required, records should be kept on site waterings, and soil moisture should be monitored at the site to ensure that it is adequate for seedling survival and establishment.

The source of seedlings and the time of planting may have also affected plant survival. Aspen seeds collected within the reservoir area were not viable, so all of the aspens that were planted came from Drayton Valley, over 400 km north of the reservoir area. As this stock did not evolve under the specific environmental conditions of this area, it may not have survived as well as native

stock would have. Most natural aspen regeneration occurs by root suckers (Peterson and Peterson 1992). Establishment by seed is more difficult, and if production of seedlings continues to be a problem, other methods of propagation should be attempted before resorting to using planting stock from outside the immediate area. Although aspen is not easily established by stem cuttings, it can be successfully propagated by root cuttings or green cuttings taken from suckers (Maini and Horton 1966; Starr 1971; Zufa 1971). Propagation through tissue culture also shows promise for difficult to root species such as aspen (Peterson and Peterson 1992).

The time of planting may have also influenced initial survival. Spring is considered to be the best time for planting aspen, while late summer or fall is usually the least successful (Peterson and Peterson 1992). All of the aspen plants that were sampled were either planted in fall 1992, or summer 1993. The exact date and moisture conditions at the time of planting are unknown. The planting stock (except for one site) was in relatively large (4L) containers, which gives more leeway in planting date. Average survival of those planted in summer was slightly higher than that for those planted in fall, but these effects may have been influenced or obscured by other variables including site conditions, and time between planting and sampling.

3.3 Choke cherry

3.3.1 Survival

Of the 858 choke cherry plants planted in 1991 and sampled in 1994 and 1995, the overall survival was 48% (Table 6a). The sampled plantings consist of three different heights of seedlings (measured in 1992): 45, 25, and 15 cm tall. For those sites sampled three years after planting, survival was highest (81%) for the site recorded as having 45 cm tall plants in 1992, and lowest (average of 28%) for the remaining three sites that were recorded as having 15 cm tall plants (Table 6b). For those sampled four years after planting, the site with 25 cm tall plants in 1992 had a higher average survival rate (84%) than the one with 15 cm tall plants (50%) (Table 6b).

Ignoring differences in time between planting and sampling, survival was highest for the taller plants, with the survival of 25 cm plants (based on only 2% of the sampled plants) being slightly greater than that for 45 cm tall plants (based on 34% of the plants counted). Survival was lowest (an average of 29%) for the three sites (accounting for 64% of the total choke cherries sampled) that originally contained 15 cm plants in 1992 (Table 6b).

When grouped by planting site preparation alone, survival for those with fabric squares was almost twice as high as survival for those with fabric strips (Table 6c). However, many factors other than planting site preparation may have influenced this result.

Surviving choke cherry were generally healthy and appeared to be growing well (Table 7 and 8). Although choke cherry survival (48%) is not particularly high, these plants should eventually increase as new shoots spread by root suckering. Regeneration by suckers was already occurring within a few of the planting sites. One site (Peninsula) had at least 17 suckers that were comparable in height to the planted seedlings. Natural regeneration of choke cherry was also noted in the vicinity of some of the sites, with natural suckers often appearing healthier than the planted ones. However, the patches of established tall choke cherry shrubs seen near the sampling sites were always very heavily browsed and usually damaged by insects or diseases and infested with weeds.

Two of the six sites compared (approximately 36% of the total choke cherry sampled), appeared to be doing quite well, with 81% (Peninsula) and 84% (Gifford's) survival. One site (Hay's) had a survival rate of 50%. This site contained less than 3% of the choke cherry sampled. The majority of the choke cherry sampled (61%) had a survival rate between 24% and 35% (Table 6a). These sites included OC5 mowed, Alvin Robbin's and Phil Malloff's.

Of the two successful sites, Peninsula was based on 295 expected plants. Site vegetation was seeded pasture, but it was still relatively sparse, and plants did not suffer from shading. A drip irrigation system was in place, and if functioning, may have provided adequate soil moisture. Site conditions were apparently suitable for suckering to occur within the planted site (at least 17 suckers were found).

The Gifford site is based on a very small sample (15 of an expected 18 plants). In this case a small error in the estimated amount planted will result in a relatively large difference in the percent survival obtained. Gifford's was not a particularly good site because vegetation was tall and dense, and the fabric strips were full of weeds. Of the four species planted, only choke cherry and one Douglas fir plant were found. The survival of choke cherry here may have been related to the soil and moisture conditions at the site, which was situated adjacent to check dam pond. Native choke cherry sprouts 50 cm or more tall were noted below the site closer to the water.

Plants at Hay's site which had a survival rate of 50% had to contend with shading caused by very dense site vegetation.

Of the sites with extremely poor survival, OC5 mowed was hayed for two seasons, resulting in the leaders being chopped off. Portions of the site that were not mowed were completely overgrown and choked by alfalfa and other forage species. At Alvin Robbin's, some of the fabric strips were damaged by cattle, and the loose fabric shaded some of the seedlings. Seedlings were also trampled and browsed. Noxious weeds grew out of the planting holes and in areas around the strips disturbed by cattle trampling. Phil Malloff's site was smothered in dense awnless brome. Moisture was so high that snails were seen on the plantings. Planting strips were partially ripped up, and plants were washed away where eroded gullies occurred beneath portions of the planting strips.

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Table 6a. Survival of Choke Cherry for all sites sampled in 1994 and 1995

Site name	Site #	1992 height (cm)	Weed control site prep.	Date planted	Date sampled	Total # of plants in sample		Survival (%)	
						A	B	A	B
Alvin Robble's	1	15	F-st	1991	1994	198	198	35	35
OCS mowed	2	15	F-sq	1991	1994	159	335	24	11
Phil Maleff's	3	15	F-st	1991	1994	166	166	25	25
Peninsula	4	45	F-sq	1991	1994	295	240	81	100
Hay's	5	15	F-sq	1991	1995	24	24	50	50
Gifford's	6	25	F-st	1991	1995	18	18	84	84
All sites with Choke Cherry :						858	980	48	42

A : Based on estimated amount planted in sample area. These are the figures referred to in the report.

B : Based on estimated amount and amount recorded in APWSS field notes where provided.

F-st : fabric strip, F-sq : fabric square

Table 6b. Survival of 15 cm, 25 cm, and 45 cm tall Choke Cherry seedlings
(Planted in 1991, sampled in 1994 and 1995)

Estimated height (cm), 1992	# Of years between planting and sampling	Site #'s	# Of sites in sample	Total # of plants in sample		Survival (%)	
				A	B	A	B
15	3	1,2,3	3	522	698	28	21
15	4	5	1	24	24	50	50
15	3 and 4 combined	1,2,3,5	4	546	722	29	22
25	4	6	1	18	18	84	84
45	3	4	1	295	240	81	100

A : Based on estimated amount planted in sample area. These are the figures referred to in the report.

B : Based on estimated amount and amount recorded in APWSS field notes where provided.

Table 6c. Survival of Choke Cherry for sites sampled in 1994 and 1995, grouped by site preparation

Weed control site preparation	Site #'s	# Of sites in sample	Total # of plants in sample		Survival (%)	
			A	B	A	B
Fabric squares	3,4,5	3	477	599	61	48
Fabric strips	1,3,6	3	381	381	33	33

A : Based on estimated amount planted in sample area. These are the figures referred to in the report.

B : Based on estimated amount and amount recorded in APWSS field notes where provided.

Table 6a. Survival of Choke Cherry for all sites sampled in 1994 and 1995

Site name	Site #	1992 height (cm)	Weed control site prep.	Date planted	Date sampled	Total # of plants in sample		Survival (%)	
						A	B	A	B
Alvin Robbin's	1	15	F-st	1991	1994	198	198	35	35
OCS moved	2	15	F-sq	1991	1994	159	335	24	11
Phil Maleff's	3	15	F-st	1991	1994	166	166	25	25
Peninsula	4	45	F-sq	1991	1994	295	240	81	100
Hay's	5	15	F-sq	1991	1995	24	24	50	50
Gifford's	6	25	F-st	1991	1995	18	18	84	84
All sites with Choke Cherry :						858	980	48	42

A : Based on estimated amount planted in sample area. These are the figures referred to in the report.

B : Based on estimated amount and amount recorded in APWSS field notes where provided.

F-st : fabric strip; F-sq : fabric square

Table 6b. Survival of 15 cm, 25 cm, and 45 cm tall Choke Cherry seedlings
(Planted in 1991, sampled in 1994 and 1995)

Estimated height (cm), 1992	# Of years between planting and sampling	Site #'s	# Of sites in sample	Total # of plants in sample		Survival (%)	
				A	B	A	B
15	3	1,2,3	3	522	698	28	21
15	4	5	1	24	24	50	50
15	3 and 4 combined	1,2,3,5	4	546	722	29	22
25	4	6	1	18	18	84	84
45	3	4	1	295	240	81	100

A : Based on estimated amount planted in sample area. These are the figures referred to in the report.

B : Based on estimated amount and amount recorded in APWSS field notes where provided.

Table 6c. Survival of Choke Cherry for sites sampled in 1994 and 1995, grouped by site preparation

Weed control site preparation	Site #'s	# Of sites in sample	Total # of plants in sample		Survival (%)	
			A	B	A	B
Fabric squares	2,4,5	3	477	599	61	48
Fabric strips	1,3,6	3	381	381	33	33

A : Based on estimated amount planted in sample area. These are the figures referred to in the report.

B : Based on estimated amount and amount recorded in APWSS field notes where provided.

3.3.2 Height growth

Although all sampled chokecherry were planted in 1991, heights were not estimated and recorded in the APWSS field notes until 1992. These 1992 estimates are likely very similar to what the original planted height estimate would be as the majority of sites were planted in the fall of 1991, and heights were estimated in the summer of 1992, less than a growing season after planting.

For 45 cm tall choke cherry plantings measured three years after planting, 29.3% show some growth (mostly within the 50-75 height class). The rest fell within or under the 1992 height (0-50 cm), with the majority of these in the 25-50 cm height class (Table 7a). For those planted at 15 cm tall, and measured three years after planting, 8.7% fell into the 25-50 cm range (showing definite growth). Little, if any growth was shown by 40.9% of the plants. These were recorded in the 10-25 cm height class, which would include plants showing a 5 cm decrease, to a maximum of 10 cm increase in height. The rest of the plants counted were below the height class containing the 1992 height, with 50% of these in the 1-10 cm category (Table 7a).

For the 15 cm tall plantings sampled after 4 years, 57.6% showed definite growth (between 20 and 100 cm tall), with the majority of these in the 20-30 cm height class (Table 7b). For those planted at 25 cm tall and measured 4 years after planting, 40% showed growth with the majority being in the 30-40 cm (5-15 cm growth) category. The remaining 60% fell below or within the range that contained the 1992 height. Of these, 40% were in the 10-20 range, and 20% were in the 20-30 range (Table 7b).

Heights differed between choke cherries planted at 15 cm tall in 1991 and sampled in 1994 and 1995 (Tables 7a, 7b). Those measured 4 years after planting had a much higher percentage of plants showing growth, and reached taller height classes than those measured after 3 years. This suggests that cumulative growth of choke cherry plants is occurring. However, differences seen may have also been influenced by other factors intrinsic to the sites included within the sample. In the 1994 sample, one site was accidentally mowed, one was trampled and grazed by cattle, and the third site was smothered by awnless brome. Two out of three sites also had fabric strip site preparations that created problems for planted seedlings.

Of the three sites sampled in 1995 with 15 cm plants, two showed growth, with one (Hay's) having 36% of the plants above 50 cm tall (Table 7b). Although moisture conditions appeared to be good at this site, survival was not exceptionally high probably due to competing vegetation. It was noted that the taller choke cherry plants at this site appeared to have grown beyond the effects of shading and other forms of damage, and seemed to be in good health.

Living choke cherry plants at the second site, Cowley Bridge, were also quite robust. The majority of these plants appeared to be new growth (one or two years maximum) growing from the roots.

The third site (North Fork), contained only 12 living choke cherry plants that showed growth similar to the sites measured in 1994 (Table 7b).

Sites planted with originally taller seedlings (25 and 45 cm) had fewer plants in the shorter height classes, but the majority of plants were still at or below the 1992 height. Growth did occur however, and as a result of the taller initial heights, plants were found in the taller height classes, with the majority being between 50 and 75 cm (Tables 7a, 7b). All of the planted seedlings remained under 100 cm tall, well within the reach of deer browsing.



Table 7a. Height class distribution of living Choke Cherry measured 3 years after planting
(Initially recorded as 15 cm and 45 cm tall in 1992, all sites planted in 1991, measured in 1994)

Height class cm	Frequency distribution of Choke Cherry (%)				
	15 cm				45 cm
	Alvin Robbin's	OCS moved	Phil Maleff's	Average	Peninsula
0 - 10	68.1	60.5	11.9	50.3	3.3
10 - 25	30.4	39.5	59.5	40.9	14.5
25 - 50	1.4	0	28.6	8.7	52.9
50 - 75	0	0	0	0	25.6
75 - 100	0	0	0	0	3.7
100 +	0	0	0	0	0
# Of plants measured :	69	38	42	149	242

Dotted line is placed below the height class containing the estimated height in 1992.

Table 7b. Height class distribution of living Choke Cherry measured 4 years after planting
(Initially recorded as 15 cm and 25 cm tall in 1992, all sites planted in 1991, measured in 1995)

Height class cm	Frequency distribution of Choke Cherry (%)				
	15 cm				25 cm
	Cowley Bridge	Hay's	North Fork	Average	Gifford's
0 - 10	9.2	3.6	33.3	10.5	0
10 - 20	38.5	7.1	58.3	32.4	40
20 - 30	32.3	17.9	8.3	25.7	20
30 - 40	13.8	18	0	13.3	20
40 - 50	6.2	18	0	8.6	13.3
50 - 75	0	32	0	9	6.7
75 - 100	0	4	0	1	0
100 +	0	0	0	0	0
# Of plants measured :	65	28	12	105	15

Dotted line is placed below the height class containing the estimated height in 1992.

3.3.3 Competing vegetation

Six of the eight sites with choke cherry were listed as having problems with competing vegetation including root competition, overtopping and shading damage caused by tall forage species, or by weeds growing up through the planting holes and choking out the planted seedlings. One of the remaining sites was less densely covered with mostly native species. The other site however, was seeded with forage plants, and may be problematic in the future. At the time of sampling (1994) vegetation cover was still sparse enough to be controlled by the fabric squares.

Table 7a. Height class distribution of living Choke Cherry measured 3 years after planting
(Initially recorded as 15 cm and 45 cm tall in 1992, all sites planted in 1991, measured in 1994)

Height class cm	Frequency distribution of Choke Cherry (%)				
	15 cm				45 cm
	Alvin Robbin's	OCS moved	Phil Maloff's	Average	Peninsula
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10 - 25	30.4	39.5	59.5	40.9	14.5
25 - 50	1.4	0	28.6	8.7	52.9
50 - 75	0	0	0	0	25.6
75 - 100	0	0	0	0	3.7
100 +	0	0	0	0	0
# Of plants measured :	69	38	42	149	242

Dotted line is placed below the height class containing the estimated height in 1992.

Table 7b. Height class distribution of living Choke Cherry measured 4 years after planting
(Initially recorded as 15 cm and 25 cm tall in 1992, all sites planted in 1991, measured in 1995)

Height class cm	Frequency distribution of Choke Cherry (%)				
	15 cm				25 cm
	Cowley Bridge	Hay's	North Fork	Average	Gifford's
0 - 10	9.2	3.6	33.3	10.5	0
10 - 20	38.5	7.1	58.3	32.4	40
20 - 30	32.3	17.9	8.3	25.7	20
30 - 40	13.8	18	0	13.3	20
40 - 50	6.2	18	0	8.6	13.3
50 - 75	0	32	0	9	6.7
75 - 100	0	4	0	1	0
100 +	0	0	0	0	0
# Of plants measured :	65	28	12	105	15

Dotted line is placed below the height class containing the estimated height in 1992.

3.3.3 Competing vegetation

Six of the eight sites with choke cherry were listed as having problems with competing vegetation including root competition, overtopping and shading damage caused by tall forage species, or by weeds growing up through the planting holes and choking out the planted seedlings. One of the remaining sites was less densely covered with mostly native species. The other site however, was seeded with forage plants, and may be problematic in the future. At the time of sampling (1994) vegetation cover was still sparse enough to be controlled by the fabric squares.

Three different site preparations: fabric squares, fabric strips, and no preparation, were used for the sampled choke cherry (Table 6c). As seen for aspen, plants on fabric squares had higher survival rates than fabric strips. The fabric strips were often shifted in position or torn, sometimes shading the plants. In some cases, the strips channeled water, resulting in soil erosion beneath them. Survival could not be calculated for the site with no preparation (North Fork), but the mostly native vegetation was relatively short, and not dense enough to warrant any site preparation.

3.3.4 Browsing damage

The majority (80%) of all sampled choke cherry plants showed some form of browsing damage, with 36% showing current year browsing (Table 8a). These values are slightly higher than those shown for aspen.

When the average percentages of any browsing damage and current browsing damage were compared for all 15 cm plantings and 45 cm plantings, those planted at 15 cm showed roughly half the browsing damage as those planted at 45 cm (Table 8b). This suggests that taller plants are more easily located and browsed. However, large differences in survival between plants sampled in 1994 and 1995 appear to be influencing this figure, and no firm conclusions about browse rate and planting size can be made from this data.

For those plants measured in 1994, no preferential browsing by height of seedlings was noted. 100% of both 15 cm and 45 cm plants showed some past and/or present browsing damage, and 50% of the plants showed current year browsing (Table 8b). For plants sampled in 1995, slightly higher rates for both categories of browsing damage were noted for 15 cm tall seedlings as compared to 25 cm seedlings (Table 8b). Because the difference is small, and the sample size for the 25 cm plants is 85% smaller than that for 15 cm plants, firm conclusions can not be drawn.

Choke cherry is listed as a preferred browse species for mule deer (Soper 1964). In their review of the literature on the foods of rocky mountain mule deer, Kufeld et al. (1973) found that choke cherry was consumed in moderate amounts in all seasons. Geist (1981) also noted that choke cherry was an important fall and early winter food for mule deer in Waterton Lakes National Park. Choke cherry is able to tolerate moderate browsing (Watson et al. 1980). Ferguson (1982) suggests that it would be beneficial for choke cherry seedlings to be protected from foraging animals for at least three years following establishment.

In this survey, choke cherry suffered moderate to high browsing intensity at all sites, but despite this, appeared to remain in relatively good health. In a few cases it was noted that the taller plants appeared to be more vigorous and may be better able to withstand both browsing and insect damage than smaller plants at the same site.

In their study on pin cherry (*Prunus pensylvanica* L.), Shabel and Pert (1994) found that both moose and deer preferred to browse taller plants, but despite this, there was a clear net growth advantage for plants of large initial size when the effects of competition, browsing, and compensatory growth were combined (Shabel and Pert 1994). Although firm conclusions can not be drawn from our data regarding incidence of browsing on different heights, taller seedlings had both a higher survival rate and a higher percentage of plants showing growth than the shorter seedlings.

In this survey, small mammal damage to choke cherry was rarely seen. In other studies in northern Alberta, choke cherry saplings were found to be susceptible to girdling damage caused by meadow voles and white-tailed deer mice (Radvanyi 1976).

3.3.5 Insect and disease

Although a high percentage of all choke cherry seedlings were affected by insect and/or disease (86%), actual insect and disease damage was light to moderate (Table 8a). Damage seen on choke cherry commonly included miscellaneous insect bites, holes and spots on leaves, and damage to tips of new leaves. A few folded apical leaves (bound together by silk) likely caused by a web worm or leaf roller were seen at one site (Hay's). Fungal leaf rusts were noted at two sites (OC5 mowed and Hay's), and mite galls were noticed on the leaves of native choke cherry shrubs near to one site at Hay's. Snails were noted on plants at one very moist site (Phil Malloff's). At Hay's, black, biting ants were in abundance with numerous nests within the planting holes (especially in empty holes or those with dead plantings). Their effect on the plants is unknown.

Table 8a. Incidence of damage to Choke Cherry plants for all sites assessed in 1994 and 1995

Site name	Site #	1992 height (cm)	Wood control site prep.	Year planted	Year sampled	# Of plants measured	% of total # of plants measured showing damage		
							Any browsing	Current year browsing	Insect/disease/ small mammal
Alvin Robble's	1	15	F-st	1991	1994	69	91	25	96
OC5 mowed	2	15	F-sq	1991	1994	38	29	11	71
Phil Malloff's	3	15	F-st	1991	1994	42	100	50	88
Pentlands	4	45	F-sq	1991	1994	242	74	45	98
Cowley Bridge	5	15	F-st	1991	1995	45	44	11	N/A
Hay's	6	15	F-sq	1991	1995	28	86	54	79
North Fork	7	15	none	1991	1995	12	17	0	50
Gifford's	8	25	F-st	1991	1995	15	40	20	100
Sites sampled in 1994 :						391	89	41	87
Sites sampled in 1995 :						120	52	21	78
All sites with Choke Cherry, 1994 and 1995 combined :						511	80	36	86

F-sq : fabric square; F-st : fabric strip; none : no site preparation

N/A : Not assessed at this site.

Table 8b. Incidence of damage for Choke Cherry estimated as being 15, 25 and 45 cm tall in 1992, planted in 1991, sampled in 1994 and 1995

Estimated height in 1992 (cm)	Year sampled	Site #'s	# Of sites in sample	# Of plants measured	% of total # of plants measured showing damage		
					Any browsing	Current year browsing	Insect/disease/ small mammal*
15	1994	1,2,3	3	149	100	50	88
15	1995	5,6,7	3	105	53	21	79
15	both 94 & 95	1,2,3,5,6,7	6	254	63	24	82
25	1995	8	1	15	40	20	100
45	1994	4	1	242	100	50	88

* Cowley Bridge (site # 5, 65 plants), was not included in calculating insect/disease/small mammal damage, as this information was not recorded at this site.

3.4 Douglas fir

3.4.1 Survival

Of a total of 438 estimated Douglas fir included in the sample, 58 were found alive giving an overall survival rate of 13% (Table 9a).

Plants sampled after 8 years had higher survival rates than those sampled after 4 and 3 years (Table 9b). As these figures are mostly based on a single site, and some of the samples are very small, generalizations can only be made about the specific sites, rather than the number of years between planting and sampling.

The Glass' site, planted 8 years ago, showed the highest survival rate of 40% (based on only one strip with 12 out of 30 expected plants). Hay's, a site with 247 Douglas fir plants, measured 4 years after planting, showed a survival of only 16%. The remaining two sites, Gifford's, measured 4 years after planting, and Alvin Robbin's, measured 3 years after planting, can be considered to have failed, as survival rates of 2% and 4% were found respectively (Table 9a).

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Table 9a. Survival of Douglas Fir for all sites sampled in 1994 and 1995

Site name	Site #	Weed control site prep.	Date planted	Date sampled	Total # of plants in sample		Survival (%)	
					A	B	A	B
Alvin Robble's	1	F-st	1991	1994	119	119	4	4
Gifford's	2	F-st	1991	1995	43	43	2	2
Hay's	3	F-sq	1991	1995	247	247	16	16
Glass'	4	none	1987	1995	38	45	40	27
All sites with Douglas Fir :					438	453	13	13

A : Based on estimated amount planted in sample area. These are the figures referred to in the report.

B : Based on estimated amount and amount recorded in APWSS field notes where provided.

F-sq : fabric square; F-st : fabric strip; none : no site preparation

Table 9b. Survival of Douglas Fir at sites sampled 3, 4, and 8 years after planting

Time between planting and sampling	Site #'s	# Of sites in sample	Total # of plants in sample		Survival (%)	
			A	B	A	B
3 years	1	1	119	119	4	4
4 years	2,3	2	290	290	14	14
8 years	4	1	38	45	40	27

A : Based on estimated amount planted in sample area. These are the figures referred to in the report.

B : Based on estimated amount and amount recorded in APWSS field notes where provided.

Table 9c. Survival of Douglas Fir for sites sampled in 1994 and 1995, grouped by site preparation

Weed control site preparation	Site #'s	# Of sites in sample	Total # of plants in sample		Survival (%)	
			A	B	A	B
Fabric squares	3	1	247	247	16	16
Fabric strips	1,2	2	162	162	4	4
No site preparation	4	1	38	45	40	27

A : Based on estimated amount planted in sample area. These are the figures referred to in the report.

B : Based on estimated amount and amount recorded in APWSS field notes where provided.

3.4.2 Height growth

Height of planted Douglas fir was estimated in 1992 as being 30 cm tall for Gifford's site, and 25 cm tall for the remaining four sites. Because most of the 1991 sites were planted in the fall, the 1992 summer height estimate would likely still be similar to the original planted height. The original height of those planted at Glass's site in 1987 is unknown.

For the site measured 3 years after planting, (Alvin Robbin's), all of the plants were below the 1992 height with the majority in the 0-10 cm height class (Table 10). For those measured 4 years after planting, roughly 12% showed growth with 8.5% in the 30-40 cm range, and 3.4% in the 40-50 cm range. The rest of the living plants were at or below the 1992 height range with the majority of these (45.8%) in 10-20 cm height class (Table 10). For the site measured 8 years after planting, approximately 17% showed some growth (up to 10 cm maximum), with the rest at or below the 1992 height, the majority (58.3%) in the 10-20 cm height class (Table 10).

Douglas fir seedlings were planted at the two year old stage (Nilson, pers. comm. 1995). Therefore, the trees were either 5, 6 or 10 years old at the time of sampling, and the majority of these were below the 25-30 cm seedling height stage. Almost all of these plants possess a rounded shrubby stunted growth form. At Glass' it was noted that most of the plants appear to have died back and re-grown from the roots or the base of the stem, as indicated by a dead central stem with new branches coming up from the base of the plant. New growth was estimated at around three years old by counting yearly growth scars. All plants found at Cowley Bridge (not included in the survival calculations) had also died back with only new sprouts under 10 cm tall present. Most of the plants at Hay's were also shrubby and stunted, but a few (possibly larger or healthier plants to begin with) were in the 30-40 and 40-50 cm height class, and appeared to have grown tall enough to be able to better withstand the damage that was affecting the others.

Table 10. Height class distribution of Douglas Fir for sites measured 3, 4, or 8 years after planting
(Plants initially recorded as 25-30 cm tall in 1992)

Height class cm	Frequency distribution of Douglas Fir (%)					
	3 Years (a)		4 Years (b)			8 Years (c)
	Alvin Robbin's	Cowley Bridge	Gifford's	Hay's	Average	Glass'
0 - 10	60	100	0	20	23.7	0
10 - 20*	40	0	100	47.3	45.8	58.3
20 - 30	0	0	0	20	18.6	25
30 - 40	0	0	0	9	8.5	16.7
40 - 50	0	0	0	4	3.4	0
50 - 75	0	0	0	0	0	0
75 - 100	0	0	0	0	0	0
100 +	0	0	0	0	0	0
# Of plants measured :	5	3	1	55	59	12

* 10 - 25 for site sampled in 1994 (Alvin Robbin's)

(a): Planted in 1991, measured in 1994; (b): Planted in 1991, measured in 1995; (c): Planted in 1987, measured in 1995

Dotted line is placed below the height class containing the estimated height in 1992.

Table 9a. Survival of Douglas Fir for all sites sampled in 1994 and 1995

Site name	Site #	Weed control site prep.	Date planted	Date sampled	Total # of plants in sample		Survival (%)	
					A	B	A	B
Alvin Robbin's	1	F-st	1991	1994	119	119	4	4
Gifford's	2	F-st	1991	1995	43	43	2	2
Hay's	3	F-sq	1991	1995	247	247	16	16
Glam'	4	none	1987	1995	30	45	40	27
All sites with Douglas Fir :					438	453	13	13

A : Based on estimated amount planted in sample area. These are the figures referred to in the report.

B : Based on estimated amount and amount recorded in APWSS field notes where provided.

F-sq : fabric square; F-st : fabric strip; none : no site preparation

Table 9b. Survival of Douglas Fir at sites sampled 3, 4, and 8 years after planting

Time between planting and sampling	Site #'s	# Of sites in sample	Total # of plants in sample		Survival (%)	
			A	B	A	B
3 years	1	1	119	119	4	4
4 years	2,3	2	290	290	14	14
8 years	4	1	30	45	40	27

A : Based on estimated amount planted in sample area. These are the figures referred to in the report.

B : Based on estimated amount and amount recorded in APWSS field notes where provided.

Table 9c. Survival of Douglas Fir for sites sampled in 1994 and 1995, grouped by site preparation

Weed control site preparation	Site #'s	# Of sites in sample	Total # of plants in sample		Survival (%)	
			A	B	A	B
Fabric squares	3	1	247	247	16	16
Fabric strips	1,2	2	162	162	4	4
No site preparation	4	1	30	45	40	27

A : Based on estimated amount planted in sample area. These are the figures referred to in the report.

B : Based on estimated amount and amount recorded in APWSS field notes where provided.

3.4.2 Height growth

Height of planted Douglas fir was estimated in 1992 as being 30 cm tall for Gifford's site, and 25 cm tall for the remaining four sites. Because most of the 1991 sites were planted in the fall, the 1992 summer height estimate would likely still be similar to the original planted height. The original height of those planted at Glass's site in 1987 is unknown.

For the site measured 3 years after planting, (Alvin Robbin's), all of the plants were below the 1992 height with the majority in the 0-10 cm height class (Table 10). For those measured 4 years after planting, roughly 12% showed growth with 8.5% in the 30-40 cm range, and 3.4% in the 40-50 cm range. The rest of the living plants were at or below the 1992 height range with the majority of these (45.8%) in 10-20 cm height class (Table 10). For the site measured 8 years after planting, approximately 17% showed some growth (up to 10 cm maximum), with the rest at or below the 1992 height, the majority (58.3%) in the 10-20 cm height class (Table 10).

Douglas fir seedlings were planted at the two year old stage (Nilson, pers. comm. 1995). Therefore, the trees were either 5, 6 or 10 years old at the time of sampling, and the majority of these were below the 25-30 cm seedling height stage. Almost all of these plants possess a rounded shrubby stunted growth form. At Glass' it was noted that most of the plants appear to have died back and re-grown from the roots or the base of the stem, as indicated by a dead central stem with new branches coming up from the base of the plant. New growth was estimated at around three years old by counting yearly growth scars. All plants found at Cowley Bridge (not included in the survival calculations) had also died back with only new sprouts under 10 cm tall present. Most of the plants at Hay's were also shrubby and stunted, but a few (possibly larger or healthier plants to begin with) were in the 30-40 and 40-50 cm height class, and appeared to have grown tall enough to be able to better withstand the damage that was affecting the others.

Table 10. Height class distribution of Douglas Fir for sites measured 3, 4, or 8 years after planting
(Plants initially recorded as 25-30 cm tall in 1992)

Height class cm	Frequency distribution of Douglas Fir (%)					
	3 Years (a)	4 Years (b)				8 Years (c)
	Alvin Robbin's	Cowley Bridge	Gifford's	Hay's	Average	Glass'
0 - 10	60	100	0	20	23.7	0
10 - 20*	40	0	100	47.3	45.8	58.3
20 - 30	0	0	0	20	18.6	25
30 - 40	0	0	0	9	8.5	16.7
40 - 50	0	0	0	4	3.4	0
50 - 75	0	0	0	0	0	0
75 - 100	0	0	0	0	0	0
100 +	0	0	0	0	0	0
# Of plants measured :	5	3	1	55	59	12

* 10 - 25 for site sampled in 1994 (Alvin Robbin's)

(a) : Planted in 1991, measured in 1994; (b) : Planted in 1991, measured in 1995; (c) : Planted in 1987, measured in 1995

Dotted line is placed below the height class containing the estimated height in 1992.

3.4.3 Competing vegetation

Although relatively shade tolerant as compared to the other planted species, overtopping by competing site vegetation may have still been a major factor involved in reducing survival of sampled Douglas fir. In natural stands of Douglas fir in this area, the understory usually consists of a sparse shrub and herb layer (Hardy Associates 1986). Almost all (5 out of 6) of the sampled planting sites were overgrown by introduced forage species or choked by weeds growing out of the planting holes. Fabric squares at Hay's site were often smothered by dense awnless brome or crested wheat grass making it difficult to locate and count the plants underneath the heavy thatch. At Gifford's and Alvin Robbin's, most of the holes of the fabric strips were filled with grass and other weedy plants. Damaged fabric strips at these sites may have contributed to shading and killing of some plants. Sites with fabric squares had a slightly higher survival than those planted with fabric strips (Table 9c).

The vegetation at the site with the highest survival (Glass' site) was native grassland dominated by *Stipa* and *Agropyron*. Although there was no site preparation, seedlings were not overtopped and smothered as at other sites. Competition for moisture and nutrients may still have been a factor as the roots of established native grassland are highly efficient at competing for these resources.

Reduction of competing site vegetation is necessary for the survival of existing and future plantings. This should be done in conjunction with the application of a deer repellent, or deer proof fencing, as reducing the surrounding vegetation will make the trees more visible to deer. Studies have shown that when Douglas fir seedlings are exposed, they are more heavily browsed (up to 50% more often) than when deer movement or vision is impeded by surrounding stumps or logs, shrub thickets, or other dense vegetation (Mitchell 1964).

3.4.4 Browsing damage

General browsing damage was noted for 62% of all sampled Douglas fir, but only 16% showed current year browsing damage (Table 11a). These rates are slightly lower than those for aspen.

Douglas fir has been cited as an important mid- to late winter food of mule deer in Waterton Lakes National park and the Porcupine Hills in Alberta (Geist 1981; Berg 1983). Deer browsing has been noted to causes serious damage to young Douglas fir in the Pacific Northwest (Black et al. 1979). Browsing of seedlings is also prevalent throughout coastal British Columbia, however, it rarely can be cited as the sole cause of seedling failure. In a study on browsing damage on Douglas fir plantation on Vancouver island, it was found that feeding was heaviest on trees less than 4 feet (approximately 122 cm) in height. The proportion of leaders damaged annually decreased rapidly after they reached 3 feet (approximately 91 cm), and was negligible after trees reached 4.5 feet (approximately 137 cm) (Mitchell 1964).

Smreciu and Hobden noted that in the mitigation planting plots they surveyed in 1989, continued browsing by deer was one cause of poor health and high mortality, especially for Douglas fir (Smreciu and Hobden 1992). In the current study, although little distinct browsing damage such as pinched off, or torn leaders was noted, a hedged growth form was seen on many of the plants. This stunted, highly branched form may have been caused by past browsing damage, however, this may also be the result of insect or frost damage, which is discussed in later sections. In order to determine whether browsing was a cause of this damage, in sites with suspected heavy winter browsing damage, exclosure studies and specific browsing surveys should be undertaken.

If taller plants are used in subsequent plantings, and these and the original plantings are protected from browsing using deer repellents or other methods until they grow past the vulnerable height, better survival and growth will likely be achieved. Mitchell (1964) noted that Douglas fir seedlings were very resilient and could recover from severe browsing damage sustained in the initial years after planting.

At Hay's site there was some evidence of small mammal damage to Douglas fir seedlings. In some instances it appeared that lower branches were browsed, and on a few plants, the main stem was gnawed off at an angle suggesting hare damage. Occasionally partial girdling (a patch of missing bark on the lower stem often caused by deer mice or voles) was also noted. Dead stems were checked for evidence of girdling damage, but usually bark was falling off from decay, making definite diagnosis difficult. Fabric squares (and likely the protected hollows underneath squares) received heavy traffic by small rodents as noted by the abundance of mice and/or vole scat on the fabric, and in planting holes.

3.4.5 Insect and disease

The majority of Douglas fir were affected to some extent by some form of insect and/or disease damage (Table 11a). The highly branched (bushy) appearance seen in some plants, often attributed to winter damage or browsing damage, can also result from insect damage.

At the site with the highest survival (Glass' site), health appeared to be poor, and every living plant appeared to be damaged in some way (Table 11a). A dieback appears to have occurred in the past, and the new branches have subsequently grown back in a bushy form from the base of the dead main leader, or from the roots. Some needles were orange, and often needles on branch tips were orange and curled suggesting insect or frost damage. Douglas fir may be host to the fungal *Scleroderris* canker, of which the strain in North America usually only attacks young trees. This pathogen causes orange discoloration at the base of needles in the spring, and may eventually cause a dieback of branches (Hiratsuka 1987).

The mountain pine beetle may also attack Douglas fir, causing the needles to turn yellowish then reddish brown the next summer (Ives and Wong 1988). In a few cases, needles appeared to be bitten off indicating possible caterpillar or looper feeding damage. Common defoliators occurring in southwestern Alberta, and feeding primarily on Douglas fir include the western false hemlock looper *Nepytia freemani* Munroe and *Nepytia umbrosaria nigrovenaria* (Packard) (Ives and Wong 1988).

Along with possible frost damage, shoot boring insects may have also contributed to some of the damage notes to the branch tips at Hay's site. In a few instances, holes in needle tips were noted and needles turned brown starting from the tips. One plant was found with needles bitten off and bound together with silk, indicating possible feeding damage by spruce budworm or spruce tube moths (Ives and Wong 1988). Other bitten off needle tips may have been caused by caterpillars or loopers. One unusual stunted lime green colored tree was also noted but cause of damage was not discerned.

Only one stunted plant was found at Gifford's with only a small portion living. Insect or disease damage was suspected in this case. Only a few plants were found at Alvin Robbin's and these were also stunted and showed some form of insect and disease damage. It should be noted that these two sites were assessed in 1994 when specific details of insect and disease damage were not recorded.

Table 11a. Incidence of damage to Douglas Fir for all sites assessed in 1994 and 1995

Site name	Site #	Wood control site prep.	Year planted	Year sampled	# Of plants measured	% of total # of plants measured showing damage		
						Any browsing	Current year browsing	Insect/disease/ small mammal
Alvin Robble's	1	F-st	1991	1994	5	80	60	100
Cowley Bridge	2	F-st	1991	1995	3	33	0	N/A
Gifford's	3	F-st	1991	1995	1	0	0	100
Hay's	4	F-sq	1991	1995	55	55	13	78
Glass'	5	none	1987	1995	12	100	17	100
All sites with Douglas Fir :					76	62	16	84

F-sq : fabric square; F-st : fabric strip; none : no site preparation

N/A : Not assessed at this site.

Table 11.b Incidence of damage to Douglas Fir at sites sampled 1, 2, and 3 years after planting, and for all plants measured in 1994 and 1995.

Plants measured:	Site #s	# Of sites in sample	# Of plants measured*	% of total # of plants measured showing damage		
				Any browsing	Current year browsing	Insect/disease/ small mammal*
3 years	1	1	5	80	60	100
4 years	2,3,4	3	59	53	12	79
8 years	5	1	12	100	17	100
In 1994	1	1	5	80	60	100
In 1995	2,3,4,5	4	71	61	13	82

* Cowley Bridge (site # 2, 3 plants), was not included in calculating insect/disease/small mammal damage as this information was not recorded at this site.

3.4.6 Abiotic factors

Important factors such as climate, terrain and soils, not specifically assessed in this survey, may have played a major role in the survival and growth of the Douglas fir plantings. In the Oldman River Reservoir area, Douglas fir is naturally found growing on sheltered north to northwest or northeast facing, moderate to steep slopes, of shallow lacustrine material and moraine over bedrock (Hardy Associates 1986). The soils (regosols) are usually sandy textured, gravelly and well drained. Douglas fir are also occasionally found on drier south and west facing slopes, with rapidly drained coarse textured soils, but only where adequate groundwater is available (Hardy Associates 1986).

Soil moisture and depth to water table are expected to greatly influence whether a plant is likely to survive in the planted area. Therefore irrigation systems and watering schedules should be assessed to insure that they are supplying sufficient moisture for seedling establishment. Site water table levels should also be measured to evaluate whether the species planted at the site can be expected to survive when initial irrigation is discontinued. A stunted growth form (seen at most sites) and occasional chlorosis may be indicative of moisture or nutrient deficiencies. Deficiency symptoms may be also linked to pH levels which affect the ion availability to plants. The alkalinity of the soil was listed as being one likely factor in the demise of Douglas fir in Smrečiu and Hobden's preliminary assessment in 1989. Soil pH should be tested in sites where this is suspected, and if feasible, the soil could be amended to make conditions more suitable for survival.

In future plantings, abiotic site conditions including soil characteristics, moisture (depth of water table), and topography should be assessed initially in order to more carefully match vegetation with suitable sites.

Winter-related tree damage can be caused by low winter temperatures, as well as various combinations of climatic conditions such as an alternation of freezing and thawing, sun exposure followed by cold temperatures, frost occurring in late spring or early fall, and wind exposure during the winter (Hiratsuka 1987). Rapid temperature changes associated with frequent chinook winds, and the highly variable number of frost free days of this region may also have contributed to some of the damage and plant diebacks seen in this study. Winter desiccation was listed by Smrečiu and Hobden (1991) as a likely factor for poor health seen in Douglas fir. At Hay's site, most of the plants had several branch tips that were wilted and orange brown to maroon in color. These symptoms may be attributed to frost damage. Some needles were enlarged and twisted, another symptom of past frost damage (Zalasky 1986). It is suggested that a more detailed investigation be undertaken to determine whether the damage noted is actually caused by frost damage, or by other factors.

Some insights into damage noted in this survey may be gained by obtaining and reviewing daily climate information collected at the Pincher Creek airport weather station for the time period between planting and sampling. Records of spring frosts, and large winter temperature changes caused by chinooks may shed light on some of the diebacks found throughout the planting sites. To determine climate related damage to future plantings, it might be useful to set up experimental monitoring plots to collect daily precipitation, air temperature, and possibly soil temperature information for analyses.

Differences in planting stock may have influenced plant survival and growth. Small, bare root stock collected from within the reservoir area was transplanted without planting fabric or wood mulch to the Glass Property site in 1987. The remaining sites were planted with containerized stock of two sizes (APWSS 1994). When correctly planted, bare root stock can establish more quickly, and has a higher survival rate than containerized seedlings (McKell and Van Epps 1980). Differences in survival between stock preparations could not be analyzed statistically, and no obvious trend in survival could be discerned for smaller (90 ml) versus larger (170 ml) container size, because they all did poorly.

At one sample plot at Hay's site, planting stock was recorded as coming from Drayton Valley. Stock planted at the rest of the sample plots at Hay's, and at the rest of the planting sites came from the Pincher Creek area. The health and height of plants from Drayton Valley was rated

slightly higher, but survival was not much better than that of the Pincher Creek stock planted at the same site.

3.5 Limber pine

3.5.1 Survival

Two sites with limber pine were sampled, but neither site can be evaluated for survival. The North Fork plantings, originally done in 1991, were considered to have failed, and the site was overplanted with aspen in 1993 (Nilson, pers. comm. 1995). One site map shows the aspen polygon starting directly below and running parallel to the original 1991 plantings (polygon 2813, N.W. 3-8-1-5, vol.5, APWSS 1994). The APWSS field notes do not indicate that the aspen were planted overtop of much of the first polygon, number 2623.

Although four limber pine plants had survived to the time of sampling, it was impossible to estimate the expected number planted in the sample area. No site preparation was used initially, making dead plants and empty spots nearly impossible to locate. Many past planting spots were also covered over with the wood mulched aspen plantings. The total number planted in the site are expected to be underestimated, resulting in the overestimation of survival. The few plants noted at North Fork were stunted and in very poor health with only a few new green sprouts coming back from the living roots of plants that had died back last year.

The only other sample plot where limber pine was found was Hay's "site D". At this sample plot, eighty one stunted, but reasonably healthy living limber pine trees were counted. The polygon containing this plot was not listed as having any limber pine plantings in the APWSS field notes, only Douglas fir. As a result, no planting ratio exists for limber pine, and the planting ratios for other species in this polygon are suspect. Data from Hay's site D was subsequently excluded from survival calculations for all species.

A survival rate of 84% can be obtained for Hay's site D by dividing the number of living limber pine by the total number of living and dead limber pine found. This figure is likely high, due to the fact that the number of empty spots previously containing limber pine is unknown. This amount could therefore not be included in the total number of living and dead limber pine found, resulting in an overestimation in survival rate. It is interesting to note however, that if exactly half the intended number of Douglas fir was actually limber pine, a similar survival rate of 85% is obtained for limber pine.

3.5.2 Height growth

All limber pine counted had a very low, shrubby growth form. Assuming that all of the limber pine planted were approximately 15 cm tall in 1992 (as stated for North Fork), when sampled four years after planting, only seven percent of those surviving had shown definite growth (Table 12). Fifty two percent were in the 10-20 cm stage, with a note made indicating that the plants recorded in this height class were usually just over 10 cm tall (Table 12). Forty-one percent were in the 0-10 cm range, showing a definite decrease in height (Table 12).

The limber pine at North Fork were planted in the fall of 1991, so the 1992 summer height estimate would likely be similar to the original planted height. Limber pine seedlings were planted at 3 years of age (Nilson, pers. comm. 1995). Therefore, measured plants were approximately 7 years

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old at the time of sampling, and the majority of these were still at or below the estimated initial planting height.

In southern Alberta, limber pine is found on bare stony ridges along the edge of the prairies (Hosie 1979). In sheltered sites it may reach heights of up to 15-20 m tall, but when occurring at high elevations and/or in windswept environments, trees are often small and irregular, sometimes growing in a low, spreading form (Kuijt 1982). Because this species has no commercial value, no information was found on expected growth rates for planted seedlings to compare with the heights seen in our plantings. The lack of growth for almost all plants after four years, and the apparent reduction of height for a large portion of these suggests that growth conditions are less than optimal, and/or some form of stress or damage is affecting the growth of these plants.

Table 12. Height class distribution of living Limber Pine measured 4 years after planting
(Initially recorded as 15 cm tall in 1992, all sites planted in 1991 and measured in 1995)

Height class cm	Frequency distribution of Limber Pine (%)		
	15 cm		
	Hay's	North Fork	Average
0 - 10	38	100	41
10 - 20	54	0	52
20 - 30	5	0	5
30 - 40	2	0	2
40 - 50	0	0	0
50 - 75	0	0	0
75 - 100	0	0	0
100 +	0	0	0
# Of plants measured :	81	4	85

Dotted line is placed below the height class containing the estimated height in 1992.

3.5.3 Competing vegetation

Weeds were not considered to be a problem at the North Fork site which was mostly native grassland, and had no planting preparation. Hay's site D was covered mostly by awnless brome, with the rest being tall native vegetation. It was specifically noted that small limber pine, especially those in the 0-10 cm category, appeared to be shaded by awnless brome or choked out by dense clumps of weedy plants growing out of their planting holes in the fabric squares at Hay's site D. Two species noted to commonly occur in the planting holes (*Aster laevis* and *Solidago sp.*) are listed as the primary intermediate hosts for pine Needle Rust (Hiratsuka 1987).

3.5.4 Browsing damage

In their review of the literature on the foods of the Rocky Mountain mule deer, Kufeld et al. (1978), found occasional reference to light use of limber pine for browse in winter, but in general it was noted as occurring as only trace amounts in the diet for the rest of the year.

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0 - 10	38	100	41
10 - 20	54	0	52
20 - 30	5	0	5
30 - 40	2	0	2
40 - 50	0	0	0
50 - 75	0	0	0
75 - 100	0	0	0
100 +	0	0	0
# Of plants measured :	81	4	85

Dotted line is placed below the height class containing the estimated height in 1992.

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Although deer frequented both sites, very little deer browsing damage was noted for limber pine. Only 6% showed any browsing, and 2% showed current year browsing damage (Table 13). This was the lowest incidence of browsing seen for all of the species sampled. More palatable plants at the site, (including herbs growing out of the same planting holes as the limber pine) showed obvious signs of deer browsing, and more palatable planted species present at the site also showed high levels of both past and present browsing damage.

Although no specific references regarding small mammal damage to limber pine were found, both lodgepole pine and jack pine often suffer from girdling and stem damage caused by hares (Radvanyi 1987). They are also susceptible to damage by rodents including meadow voles and deer mice (Fedkenheuer et al. 1980). At Hay's site D, some damage was attributed to small mammals including apparent browsing of lower branches, and partial girdling damage noted on one or two plants. Microtine rodent scat (possibly from deer mice and/or red backed or meadow voles) was noted on several fabric squares, and evidence of tunneling was also noted under some of these squares.

3.5.5 Insect and disease

At Hay's site D, about half the plants showed some form of insect and disease damage, however the extent of the damage was listed as minimal (Table 13). Occasionally some shoots were eaten (possibly by a caterpillar) down to the bare stem.

Damage to the tips of some needles was also noted. Many had orange needles with blackened tips others appeared as if tips were bitten off, with the damaged tips being grayish on the very end, then reddish brown in color. Silky webs were noted on some of these plants. This type of damage might have been caused by a species of needle miner, or possibly young budworm larvae. One possibility is the closely related sugar pine tortrix (*Choristoneura lambertiana* Busck), that has been noted to cause light defoliation of limber pine in the foothills of southern Alberta (Ives and Wong 1988). Kuijt (1988) noted that in southern Alberta, especially on marginal sites, limber pine has been much damaged by White pine Blister Rust (*Cronartium ribicola* Fischer).

Table 13. Incidence of damage to Limber Pine for two sites measured 4 years after planting

Site name	Weed control site prep.	Year planted	Year sampled	# Of plants measured	% of total # of plants measured showing damage		
					Any browsing	Current year browsing	Insect/disease/ small mammal
Hay's	F-sq	1991	1995	81	6	2	49
North Fork	none	1991	1995	4	0	0	50
All sites with Limber Pine :					6	2	49

F-sq : fabric square; none : no site preparation

3.5.6 Abiotic factors

At North Fork, only four living plants were found, and all plants were within the 0-10 cm height class. In site A, both of the plants were stunted and needles were mostly browned or completely orange with only a few living green needles or branches present. At site B, the plants had died back, and the only surviving portion of plants were small new shoots growing from the roots.

This damage may be attributed to winter damage causing leader and/or root dieback. Symptoms listed for lodgepole pine for this type of damage include: severely stunted seedling form, sparse, chlorotic leaves, common defoliation, and epicormic, sparse and spindly new shoots (Zalasky 1986). This description aptly fits the few living limber pine seen at North Fork.

At Hay's site D, the growth form seen fits Zalasky's description of winter damaged lodgepole pine with bud dieback. Affected seedlings show a moderately stunted, bushy, flat topped, ball-shaped or multistemmed growth form, with generally good dense leaves, and epicormic, interfoliaceous, and normal lateral shoots (Zalasky 1986).

In most cases the needles on the lower branches were yellowish orange, or brown. This may indicate possible problems with local soil conditions. The dense growth of awnless brome and tall green needle grass at Hay's site is also indicative of relatively high moisture levels. As limber pine is usually found on rocky, dry, windswept slopes with very sparse understory vegetation, it is unlikely to be competitive growing with species present under the soil and moisture conditions occurring at these planting sites.

3.6 Northwest poplar

3.6.1 Survival

Northwest poplar was sampled at two locations within the Glass property mitigation project area. The Glass' site, located in planting polygon 2680 (N.E. 16-7-29-4, vol.1, APWSS, 1994), was assessed specifically as part of this survey in 1995. The second site, located in polygon 2674 (S.E. 21-7-29-4, vol.1, APWSS, 1994), was measured as part of the Glass property enclosure assessment in 1994. The enclosure data is further discussed in section 3.10. The data collected for the Northwest poplar plants found in the plot outside of the enclosure (referred to in this section as "Enclosure site") is combined with the data collected at the Glass' site to calculate the survival, height growth, and damage discussed in this section.

Of 143 plants sampled in 1994 and 1995 combined, only 24 were alive, giving a survival rate of 17%. Survival at the Glass' site was much lower than that at the Enclosure site. Of 127 plants sampled at Glass' site, only 9% were alive. At the Enclosure site, only 16 plants were sampled and 81% of these survived (Table 14). The large difference in survival is most likely due to differences in moisture conditions present at each site. The Glass' site was dryer and more exposed than the Enclosure site, that was situated next to a wetland.

In 1989, 298 Northwest poplar plants were assessed from plots located within the same planting projects assessed in this survey (Sec 21, Twp 7, Rg 29, W4M and Sec 16, Twp 7, Rg 29, W4M). At that time, only 2 years after planting, a much higher survival rate of 91% was found (Smreciu and Hobden 1992).

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Table 14. Survival of Northwest Poplar for sites sampled in 1994 and 1995

Site name	Weed control site prep.	Date planted	Date sampled	Total # of plants in sample	Survival (%)
Glass' site	none	1987	1995	127	9
Exclosure site	none	1987	1994	16	81
All sites with Northwest Poplar :				143	17

3.6.2 Height growth

At both sites, the height estimated in 1992 was approximately 2 to 3 feet tall (roughly between 60 and 90 cm). Overall, no growth was shown, and only 16.7% of the plants were even in the range of the 1992 heights. The remainder (83.3%) were below this height with the majority of these being between 30 and 40 cm tall (Table 15).

For Glass' site, sampled eight years after planting, all plants were below 50 cm tall, with the majority (91%) below 40 cm tall. Plants were slightly taller at the Exclosure site, with all plants being between 20 and 75 cm tall, with the majority of these between 40 and 75 cm tall (Table 15).

When used as a shelterbelt planting, Northwest poplar is noted to grow slowly in dry areas, and very fast in wetter areas (Alberta Fish and Wildlife ND). It is likely that the differences in height may also be the result of better moisture conditions at the Exclosure site.

At the Exclosure site, a dieback appears to have occurred in 1989 or 1990, as indicated by the presence of dead leaders, and a large amount of branching in the following years (date was roughly estimated by counting annual growth scars on these branches). A number of diebacks appear to have occurred at the Glass' site as evidenced by the highly branched growth form seen on all living and dead plants. The few living plants measured in 1995 were all relatively new growth (1 to 2 years maximum). These diebacks may have been caused by climatic factors including winter damage or drought stress.

Poplars measured inside the Glass property exclosure were significantly taller than those outside of the exclosure (Table 23a), indicating that deer browsing damage may have also had an effect on the height of these plants.

Table 15. Height class distribution of living Northwest Poplar planted in 1987
(Height initially recorded as being approximately 60-90 cm tall in 1992)

Height class cm	Frequency distribution of Northwest Poplar (%)		
	60 - 90 cm		
	Glass' site (a)	Exclosure site (b)	Average
0 - 10	0	0	0
10 - 20	18.2	0	8.3
20 - 30	36.4	15.4	25
30 - 40	36.4	23.1	29.2
40 - 50	9.1	30.8	20.8
50 - 75	0	30.8	16.7
75 - 100	0	0	0
100 +	0	0	0
# Of plants measured :	11	13	24

(a) : Glass' site measured in 1995; (b) : Exclosure site measured in 1994

Dotted line is placed below the height class containing the estimated height in 1992.

3.6.3 Competing vegetation

Survival of Northwest poplar at the Glass' site may have been influenced by competing vegetation. Sample plot A was covered with tall, dense forage species dominated by awnless brome. Many of the planted poplar in this site were completely engulfed by this thick vegetation, that had to be carefully dug through at the expected intervals to locate plantings. Poplars in general are not very shade tolerant. Almost all of the overtopped plants were dead, and all but one of the living plants were found in the one portion of the plot that had noticeably shorter, less dense vegetation and a larger percentage of bare ground.

Plot B, directly south of A was covered by shorter, but still very dense native grassland dominated by needle grass and wheat grasses. Although it was expected that the slightly shorter native grassland plot (B) would have had a the higher survival rate, a comparison of these two plots showed that plot B had only 1.6% survival (based on one plant) as compared to site A, with 18.9% survival (based on 10 plants). As the number of living plants is so low for both, the difference in survival may or may not be significant. Other factors such as the placement and functioning of the irrigation system may also differ between sites.

3.6.4 Browsing damage

Balsam poplar is a preferred source of browse for mule deer in Alberta. Leaves and buds are eaten in the spring and summer, and dried leaves are pawed out from under the snow in winter (Nietfeld et al. 1985). Deer browsing damage is a major concern in establishing hybrid poplar plantations in the United States (Hansen et al. 1983). Significant browsing damage to Northwest poplar was noted in the 1989 survival assessment within the same planting projects (Smreciu and Hobden 1992).

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50 - 75	0	30.8	16.7
75 - 100	0	0	0
100 +	0	0	0
# Of plants measured :	11	13	24

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Plot B, directly south of A was covered by shorter, but still very dense native grassland dominated by needle grass and wheat grasses. Although it was expected that the slightly shorter native grassland plot (B) would have had a the higher survival rate, a comparison of these two plots showed that plot B had only 1.6% survival (based on one plant) as compared to site A, with 18.9% survival (based on 10 plants). As the number of living plants is so low for both, the difference in survival may or may not be significant. Other factors such as the placement and functioning of the irrigation system may also differ between sites.

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In this survey, all living plants at both sites showed some form of browsing damage (Table 16). Less browsing damage was noted for the current year in the Glass' site sampled in 1995, than in the Exclosure site sampled in 1994 (Table 16). This may have been due to the fact that at the Glass' site, the few living plants were measured in the spring, shortly after the leaves had flushed. However, the majority of dead plants at this site exhibited a very shrubby, highly branched (at least five times from the base) growth form suggesting that some form of heavy browsing or insect damage was common in the initial years after planting.

No small mammal damage was noted on living plants, and no obvious girdling damage was seen on dead plants. Specific assessment of deer browsing and rodent damage was not done for dead plants because the bark and ends of twigs were often broken off, obscuring this damage.

3.6.5 Insect and disease

The majority (88%) of the Northwest poplar sampled showed some level of insect or disease damage (Table 16).

In the few living plants present at the Glass' site, no obvious signs of disease were noted, but most plants (73%) appeared to have sustained a moderate amount of insect damage (Table 16). Four plants showed various insect bites, possibly caused by caterpillars. One plant with similar damage had a folded leaf housing a moth larvae (perhaps *Choristoneura* sp.). Leaf beetles, their larvae, or obvious beetle damage (blackened lacy damage matching that noted on plants with the feeding beetles present) were seen on four of the eleven living plants, and on one other plant, outside of the plot. Although not collected for identification, the beetle appeared to be very similar in appearance to the cottonwood leaf beetle (*Chrysomela scripta* Fabricus). *Chrysomela scripta* prefers young foliage and is noted as being particularly troublesome on hybrid poplars (Ives and Wong 1988). Heavy populations of this beetle have been known to kill leaders causing deformed growth (Ives and Wong 1988).

Past severe outbreaks of the beetle or caterpillars observed, or other insects or diseases may have contributed to mortality and/or the stunted, highly branched growth form noted in the majority of the dead plants. In the 1989 survey, although only browsing damage was reported for Northwest poplar, severe insect damage was noted in the caragana planted in the same sites (Smreciu and Hobden 1991). When poplar are damaged by browsing or other factors, they may become more susceptible to disease or insects (Peterson and Peterson 1992).

In the Exclosure site, all plants showed some form of insect or disease damage (Table 16). It was specifically noted that over half the Northwest poplar outside of the exclosure and all of the poplar inside were infested with both aphids and ants, usually found on the buds and petioles of leaves. Based on their dark color, they were likely smokywinged poplar aphids (*Chaitophorus populicola* Thomas). These, and numerous other aphid species are known to attack the roots and stems of poplars, but damage is not thought to be of particular importance (Ives and Wong 1988). Ants that tend aphid colonies on poplars and willows do not adversely affect the host trees (Ives and Wong 1988). An orange colored leaf rust was also seen on several plants outside the exclosure. One species of leaf rust commonly found on poplar hybrids in Alberta is *Melampsora occidentalis* Jacks. (Hiratsuka 1987). This leaf rust may affect the health of trees by causing early defoliation of heavily infected leaves, but infected trees are seldom killed (Hiratsuka 1987).

Table 16. Incidence of damage to Northwest Poplar

Site name	Weed control site prep.	Year planted	Year sampled	# Of plants measured	% of total # of plants measured showing damage		
					Any browsing	Current year browsing	Insect/Albino/ small mammal
Glass' site	none	1987	1995	11	100	100	73
Exclosure site	none	1987	1994	13	100	46	100
All sites with Northwest Poplar :				24	100	71	88

3.6.6 Abiotic factors

Northwest poplar is a hybrid between *Populus deltoides* Marsh. and *P. Balsamifera* L. Poplars are normally riparian phreatophytes, obtaining water directly from the water table (Rood and Mahoney 1991). Poplars will opportunistically use rain water as a source of moisture, but in southern Alberta, the amount of precipitation is not usually sufficient to support the growth of these trees (Rood and Mahoney 1991).

The Glass' site is located on the flat to gently sloping upper portion of a south east facing slope high above the Oldman River. This site originally supported only grassland vegetation, and it is highly unlikely that there is sufficient moisture present to support the relatively high water requirements of this type of tree. If the subsurface emitter irrigation system at this site was working as planned in the initial years after planting, sufficient moisture may have been present to allow the seedlings to survive and grow for a period of time (as evidenced by the branching growth that was noted on most of the dead plants). However, it is possible that the majority of these seedlings eventually succumbed to drought stress.

Site differences such as soil type and texture, and depth of water table may play a significant role in the survival of planted seedlings. Therefore species planted at a site should be carefully matched to the site conditions to maximize plant survival and growth.

Winter desiccation was suggested as a likely cause for failure of Douglas fir and Colorado spruce in this area (Smreciu and Hobden 1991). As chinook winds are known to damage aspen branches and buds in Alberta's foothills (Peterson and Peterson 1992), it is likely that these drying winds may have also caused damage to the Northwest poplars at this site.

3.7 Rose

3.7.1 Survival

Rose was planted at two of the sampled sites, Alvin Robbin's, and OC5 mowed. Using the estimated number planted from the overall ratio at Alvin Robbin's site, a survival of approximately 344% was calculated based on finding 17 living where approximately 5 were expected (Table 17). This increase in the number of plants could be explained by natural regeneration of rose plants present at the site (coming up through empty planting strip holes). However, there is some doubt as to whether the number recorded as planted at the site (12 rose plants out of 780 total plants) is

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correct. The site plan depicted in the APWSS field notes (Polygon 2658, S.E. 24-7-1-5, vol.3, APWSS 1994) was a generalized sketch and not the final "as built" layout (including location of fabric strips). As a result, no specific information on what was planted in the various fabric strips is available. The only figures given are for the whole site.

The OC5 mowed site showed a survival of 130% (Table 17). A more conservative rate of 69% was obtained when the amount recorded in the APWSS field notes for rose was used to calculate survival. The recorded number was not considered to be correct however, because the total number of plants recorded for this site was very different from what was counted in the field. Because the site preparation was relatively permanent (fabric squares), the estimated figure based on counted planting spots was considered to be more accurate, and was therefore used to calculate survival for rose and the other species at this site. This estimation is also based on planting ratios obtained from the APWSS field notes, that may or may not accurately reflect the ratio of plants used at the site.

Table 17. Survival of Rose for all sites sampled

Site name	Weed control site prep.	Date planted	Date sampled	Total # of plants in sample		Survival (%)	
				A	B	A	B
Alvin Robbin's*	F-st	1991	1994	5	5	344	344
OC5 mowed	F-sq	1991	1994	32	61	130	69
All sites with Rose :				37	66	159	89

* Approximately 5 rose were estimated as being planted, but 17 were found, resulting in survival over 100%.

A : Based on estimated amount planted in sample area. These are the figures referred to in the report.

B : Based on estimated amount and amount recorded in APWSS field notes where provided.

F-st : fabric strip, F-sq : fabric square

3.7.2 Height growth

Height of planted rose was estimated in 1992 as being 15 cm tall. Both sites were planted in the spring of 1991, so actual planting heights may have been slightly shorter. For the two sites combined, 69% of the seedlings were in the 0-10 cm height class, below the 1992 height. Thirty percent were in the 10-25 cm class and only 2% were above the 1992 height, in the 25-50 cm class (Table 18). Both prickly rose and common wild rose are bushy shrubs averaging 50 cm to 150 cm tall (Moss 1983). After three years, all of the rose sampled were less than 50 cm tall, with the majority shorter than 15 cm. These plants are likely new sprouts coming back from damage. At Alvin Robbin's, accidental cattle grazing at the site may have contributed to this, while at OC5 mowed, the site was mowed in 1993 and 1994.

Table 18. Height class distribution of living Rose measured 3 years after planting
(Height initially recorded as being 15 cm tall in 1992, all sites planted in 1991, measured in 1994)

Height class cm	Frequency distribution of Rose (%)		
	15 cm		
	Alvin Robbin's	OC5 mowed	Average
0 - 10	85	61.4	69
10 - 25	15	36.4	30
25 - 50	0	2.3	2
50 - 75	0	0	0
75 - 100	0	0	0
100 +	0	0	0
# Of plants measured :	20	44	64

Dotted line is placed below the height class containing the estimated height in 1992.

3.7.3 Competing vegetation

Portions of the sample at Alvin Robbin's had dense weedy vegetation growing out of the planting holes. At OC5 mowed, shading damage was noted to all plants including rose by the dense alfalfa/forage grass cover on portions of the site not mowed (close to fence). This caused many of the plants to be stunted and to grow along the ground under the thick cover. In a field experiment near Edmonton, it was shown that wild rose was very effective at competing with seeded grasses (Bailey 1972). However, the extremely dense alfalfa and brome at OC5 mowed appeared to have successfully out-competed all plantings.

3.7.4 Browsing damage

Rose is known to be an excellent summer forage plant for deer. Rose hips provide additional nutritional value when present (Ferguson 1982). However, only 36% of all sample rose seedlings showed some form of browsing damage, and 25% showed current year browsing (Table 19). These rates are lower than that seen for Douglas fir.

General browsing damage at OC5 mowed was low (11%) but this damage was obscured by the mowing damage at this site (Table 19). Rose suffered moderate to heavy browsing damage at Alvin Robbin's (90%) (Table 19). However, prior to sampling, this site was grazed and trampled by cattle which probably affected the apparent rate of browsing by wildlife.

3.7.5 Insect and disease

A moderate amount of insect or disease damage was recorded for rose in both sites, with an average of 67% for both combined (Table 19). The effect of the damage on the health of the plants was not considered to be severe.

correct. The site plan depicted in the APWSS field notes (Polygon 2658, S.E. 24-7-1-5, vol.3, APWSS 1994) was a generalized sketch and not the final "as built" layout (including location of fabric strips). As a result, no specific information on what was planted in the various fabric strips is available. The only figures given are for the whole site.

The OC5 mowed site showed a survival of 130% (Table 17). A more conservative rate of 69% was obtained when the amount recorded in the APWSS field notes for rose was used to calculate survival. The recorded number was not considered to be correct however, because the total number of plants recorded for this site was very different from what was counted in the field. Because the site preparation was relatively permanent (fabric squares), the estimated figure based on counted planting spots was considered to be more accurate, and was therefore used to calculate survival for rose and the other species at this site. This estimation is also based on planting ratios obtained from the APWSS field notes, that may or may not accurately reflect the ratio of plants used at the site.

Table 17. Survival of Rose for all sites sampled

Site name	Weed control site prep.	Date planted	Date sampled	Total # of plants in sample		Survival (%)	
				A	B	A	B
Alvin Robbin's*	F-st	1991	1994	5	5	344	344
OC5 mowed	F-sq	1991	1994	32	61	130	69
All sites with Rose :				37	66	159	89

* Approximately 5 rose were estimated as being planted, but 17 were found, resulting in survival over 100%.

A : Based on estimated amount planted in sample area. These are the figures referred to in the report.

B : Based on estimated amount and amount recorded in APWSS field notes where provided.

F-st : fabric strip; F-sq : fabric square

3.7.2 Height growth

Height of planted rose was estimated in 1992 as being 15 cm tall. Both sites were planted in the spring of 1991, so actual planting heights may have been slightly shorter. For the two sites combined, 69% of the seedlings were in the 0-10 cm height class, below the 1992 height. Thirty percent were in the 10-25 cm class and only 2% were above the 1992 height, in the 25-50 cm class (Table 18). Both prickly rose and common wild rose are bushy shrubs averaging 50 cm to 150 cm tall (Moss 1983). After three years, all of the rose sampled were less than 50 cm tall, with the majority shorter than 15 cm. These plants are likely new sprouts coming back from damage. At Alvin Robbin's, accidental cattle grazing at the site may have contributed to this, while at OC5 mowed, the site was mowed in 1993 and 1994.

Table 18. Height class distribution of living Rose measured 3 years after planting
(Height initially recorded as being 15 cm tall in 1992, all sites planted in 1991, measured in 1994)

Height class cm	Frequency distribution of Rose (%)		
	15 cm		
	Alvin Robbin's	OC5 mowed	Average
0 - 10	85	61.4	69
10 - 25	15	36.4	30
25 - 50	0	2.3	2
50 - 75	0	0	0
75 - 100	0	0	0
100 +	0	0	0
# Of plants measured :	20	44	64

Dotted line is placed below the height class containing the estimated height in 1992.

3.7.3 Competing vegetation

Portions of the sample at Alvin Robbin's had dense weedy vegetation growing out of the planting holes. At OC5 mowed, shading damage was noted to all plants including rose by the dense alfalfa/forage grass cover on portions of the site not mowed (close to fence). This caused many of the plants to be stunted and to grow along the ground under the thick cover. In a field experiment near Edmonton, it was shown that wild rose was very effective at competing with seeded grasses (Bailey 1972). However, the extremely dense alfalfa and brome at OC5 mowed appeared to have successfully out-competed all plantings.

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General browsing damage at OC5 mowed was low (11%) but this damage was obscured by the mowing damage at this site (Table 19). Rose suffered moderate to heavy browsing damage at Alvin Robbin's (90%) (Table 19). However, prior to sampling, this site was grazed and trampled by cattle which probably affected the apparent rate of browsing by wildlife.

3.7.5 Insect and disease

A moderate amount of insect or disease damage was recorded for rose in both sites, with an average of 67% for both combined (Table 19). The effect of the damage on the health of the plants was not considered to be severe.

Table 19. Incidence of damage to Rose for two sites measured 3 years after planting

Site name	Weed control site prep.	Year planted	Year sampled	# Of plants measured	% of total # of plants measured showing damage		
					Any browsing	Current year browsing	Insect/disease/ small mammal
Alvin Robbin's	F-st	1991	1994	20	90	70	80
OC5 mowed	F-sq	1991	1994	44	11	5	61
All sites with Rose :				64	36	25	67

F-sq : fabric square; F-st : fabric strip

3.7.6 Abiotic factors

At OC5 mowed, damage to the leaders was caused by accidental mowing of the site. Fortunately, rose is known to re-sprout from the roots if cut or burned (Watson et al. 1980). The high survival of rose despite this mowing damage suggests that this was occurring at this site.

3.8 Saskatoon

3.8.1 Survival

Of a total of 638 plants sampled, a survival rate of 48% was found, with survival at individual sites ranging between 0 and 54% (Table 20a).

In 1992, estimated saskatoon seedling heights fell into 3 different classes: 45 cm, 25 cm and 15 cm. As all but one of these sites were planted in the fall of 1991, original planted heights are likely similar to these summer 1992 estimates. For sites sampled in 1994, the 45 cm tall plants had a slightly higher survival rate (54%) than did 15 cm plants (45%) (Table 20b). Few plants were sampled in 1995, and survival at both of the sampled sites was low. No plants were found alive at the Gifford site that had 25 cm tall seedlings in 1992. The Hay's site that had 15 cm tall seedlings in 1992 showed a survival rate of 13% (Table 20b).

The site with the highest survival rate (Peninsula), originally had 45 cm tall seedlings (Table 20a). These plants may have been better able to withstand browsing or other forms of damage or stress compared to smaller seedlings. Survival may also have been improved because competing vegetation was low at this site.

The OC5 mowed site had the second highest survival rate (Table 20a). Although the plants were still alive, they were in poor stunted condition due to shading damage caused by a dense cover of alfalfa and other forage species, and by mowing of most of the site for two seasons.

The three sites with low survival rates (between 0 and 31%, Table 20a), suffered from severe competition with site vegetation (shading over, vegetation growing in planting holes). Two of the three sites had fabric strip preparations that were choked with weeds, and in one case partially

ripped off, with an eroded channel occurring underneath a portion of it. Moderate to heavy insect/disease and browsing damage were also noted for these sites.

Table 20a. Survival of Saskatoon for all sites sampled in 1994 and 1995

Site name	Site #	1992 height (cm)	Weed control site prep.	Date planted	Date sampled	Total # of plants in sample		Survival (%)	
						A	B	A	B
Phil Maloff's	1	15	F-st	1991	1994	51	51	31	31
OCS moved	2	15	F-sq	1991	1994	264	533	49	19
Peninsula	3	45	F-sq	1991	1994	348	284	54	66
Hay's	4	15	F-sq	1991	1995	23	23	13	13
Gifford's	5	25	F-st	1991	1995	12	12	0	0
All sites with Saskatoon :						638	903	48	34

A : Based on estimated amount planted in sample area. These are the figures referred to in the report.

B : Based on estimated amount and amount recorded in APWSS field notes where provided.

F-st : fabric strip; F-sq : fabric square

Table 20b. Survival of 15 cm, 25 cm, and 45 cm tall Saskatoon seedlings

Estimated height (cm), 1992	# Of years between planting and sampling	Site #'s	# Of sites in sample	Total # of plants in sample		Survival (%)	
				A	B	A	B
15	3	1,2	2	255	584	45	20
15	4	4	1	23	23	13	13
15	3 and 4 combined	1,2,4	3	278	607	42	19
25	4	5	1	12	12	0	0
45	3	3	1	348	284	54	66

A : Based on estimated amount planted in sample area. These are the figures referred to in the report.

B : Based on estimated amount and amount recorded in APWSS field notes where provided.

Table 20c. Survival of Saskatoon for sites sampled in 1994 and 1995, grouped by site preparation

Weed control site preparation	Site #'s	# Of sites in sample	Total # of plants in sample		Survival (%)	
			A	B	A	B
Fabric squares	2,3,4	3	575	840	50	34
Fabric strips	1,5	2	63	63	25	25

A : Based on estimated amount planted in sample area. These are the figures referred to in the report.

B : Based on estimated amount and amount recorded in APWSS field notes where provided.

ripped off, with an eroded channel occurring underneath a portion of it. Moderate to heavy insect/disease and browsing damage were also noted for these sites.

Table 20a. Survival of Saskatoon for all sites sampled in 1994 and 1995

Site name	Site #	1992 height (cm)	Weed control site prep.	Date planted	Date sampled	Total # of plants in sample		Survival (%)	
						A	B	A	B
Phil Maleff's	1	15	F-st	1991	1994	51	51	31	31
OCS mowed	2	15	F-sq	1991	1994	284	533	49	19
Peninsula	3	45	F-sq	1991	1994	348	284	54	66
Hay's	4	15	F-sq	1991	1995	23	23	13	13
Gifford's	5	25	F-st	1991	1995	12	12	0	0
All sites with Saskatoon :						638	903	48	34

A : Based on estimated amount planted in sample area. These are the figures referred to in the report.

B : Based on estimated amount and amount recorded in APWSS field notes where provided.

F-st : fabric strip, F-sq : fabric square

Table 20b. Survival of 15 cm, 25 cm, and 45 cm tall Saskatoon seedlings

Estimated height (cm), 1992	# Of years between planting and sampling	Site #'s	# Of sites in sample	Total # of plants in sample		Survival (%)	
				A	B	A	B
15	3	1,2	2	255	584	45	20
15	4	4	1	23	23	13	13
15	3 and 4 combined	1,2,4	3	278	607	43	19
25	4	5	1	12	12	0	0
45	3	3	1	348	284	54	66

A : Based on estimated amount planted in sample area. These are the figures referred to in the report.

B : Based on estimated amount and amount recorded in APWSS field notes where provided.

Table 20c. Survival of Saskatoon for sites sampled in 1994 and 1995, grouped by site preparation

Weed control site preparation	Site #'s	# Of sites in sample	Total # of plants in sample		Survival (%)	
			A	B	A	B
Fabric squares	2,3,4	3	575	840	50	34
Fabric strips	1,5	2	63	63	25	25

A : Based on estimated amount planted in sample area. These are the figures referred to in the report.

B : Based on estimated amount and amount recorded in APWSS field notes where provided.

3.8.2 Height growth

Saskatoon is a shrub or small tree from 1-6 m in height (Moss 1983). All of the saskatoon plants measured in this study, measured 3 and 4 years after planting, were under one meter tall (Table 21a). For plants measured in 1994 (3 years after planting), the seedlings that were approximately 45 cm tall in 1992 had a higher proportion showing growth than those that were 15 cm tall in 1992. For those originally 45 cm tall, 23.5% showed some growth, with the majority in the 50-75 cm height class. The rest of the plants were between 0 and 50 cm tall, with approximately a quarter of the plants in the 0-10 cm height class, indicating that some form of dieback occurred in the past (Table 21a).

For plants estimated as being 15 cm tall in 1992, and measured 3 years after planting, only 3.5% showed definite growth. The majority (97%) were under 25 cm tall with 37% showing a definite decrease (in the 0-10 cm class) indicating that some factor caused these plants to dieback. Sixty percent were in the height category containing the 1992 height (10-25 cm class). This could account for a decrease in height of up to 5 cm, or an increase of up to 10 cm over the original height (Table 21a).

Saskatoon plants originally 15 cm tall in 1992 and measured 4 years after planting (1995) showed the greatest increase in height, with 46% between 20 and 75 cm tall. Fifty four percent were in the 10-20 cm height category (showing no real growth) but none were in the 0-10 cm height class. This suggests that if these plants also suffered from the dieback that affected plants sampled in 1994, then these plants had recovered and had grown into the next height class over the year (Table 21b).

Table 21a. Height class distribution of living Saskatoon measured 3 years after planting
(Estimated as 15 cm and 45 cm tall in 1992, all sites planted in 1991, measured in 1994)

Height class cm	Frequency distribution of Saskatoon (%)			
	15 cm			45 cm
	OC5 moved	Phil Maleff's	Average	Peninsula
0 - 10	41.4	6.3	36.5	24
10 - 25	54.5	93.8	60	10.9
25 - 50	4	0	3.5	41.5
50 - 75	0	0	0	23
75 - 100	0	0	0	0.5
100 +	0	0	0	0
# Of plants measured :	99	16	115	183

Dotted line is placed below the height class containing the estimated height in 1992.

Table 21b. Height class distribution of living Saskatoon measured 4 years after planting
(Initially estimated as being 15 cm tall in 1992, all sites planted in 1991, measured in 1995)

Height class	Frequency distribution of Saskatoon (%)			
	15 cm			
	Cowley Bridge	Hay's	North Fork	Average
cm				
0 - 10	0	0	0	0
10 - 20	66.7	10	50	54
20 - 30	33.3	30	50	34
30 - 40	0	40	0	8
40 - 50	0	10	0	2
50 - 75	0	10	0	2
75 - 100	0	0	0	0
100 +	0	0	0	0
# Of plants measured :	36	10	4	50

Dotted line is placed below the height class containing the estimated height in 1992.

3.8.3 Competing vegetation

Although it is relatively shade tolerant, saskatoon prefers to grow in open sites (Watson et al. 1980). Four out of five sites were suffering from severe competing vegetation problems. The remaining site may also become overgrown in a year or two because the site vegetation is mainly comprised of seeded forage species. Heavy shading and choking out of the plants at these sites likely contributed to the low rates of survival and growth.

3.8.4 Browsing damage

Sampled seedlings showed moderate browsing damage, slightly higher than that recorded for aspen. Sixty nine percent showed past and/or present browsing damage, whereas 30% showed current year browsing (Table 22a). Seedlings estimated as being 45 cm tall in 1992 showed the highest incidence of browsing damage (97%) (Table 22b).

Saskatoon is listed as an important fall and early winter food of mule deer (Geist 1981). This species is able to tolerate moderate browsing, although hedging may occur if plants are heavily browsed (Watson et al. 1980). Shrubs tend to be browsed more than seedlings. Remaining patches of taller native saskatoon shrubs seen near the survey sites, (as with all palatable shrub species) were noted to be in very poor shape as a result of heavily utilization by deer.

In a study of woody plant establishment in northern Alberta, saskatoon received the highest rodent damage among the deciduous species tested, but it was able to re-grow quite well by re-sprouting from the roots (Fedkenheuer et al. 1980). In the sampled sites, generally minor damage attributed to rodents was noted. However, at one sample plot at Hay's site, there were signs of small mammal use and moderate small mammal damage was noted on Douglas fir, but no living

3.8.2 Height growth

Saskatoon is a shrub or small tree from 1-6 m in height (Moss 1983). All of the saskatoon plants measured in this study, measured 3 and 4 years after planting, were under one meter tall (Table 21a). For plants measured in 1994 (3 years after planting), the seedlings that were approximately 45 cm tall in 1992 had a higher proportion showing growth than those that were 15 cm tall in 1992. For those originally 45 cm tall, 23.5% showed some growth, with the majority in the 50-75 cm height class. The rest of the plants were between 0 and 50 cm tall, with approximately a quarter of the plants in the 0-10 cm height class, indicating that some form of dieback occurred in the past (Table 21a).

For plants estimated as being 15 cm tall in 1992, and measured 3 years after planting, only 3.5% showed definite growth. The majority (97%) were under 25 cm tall with 37% showing a definite decrease (in the 0-10 cm class) indicating that some factor caused these plants to dieback. Sixty percent were in the height category containing the 1992 height (10-25 cm class). This could account for a decrease in height of up to 5 cm, or an increase of up to 10 cm over the original height (Table 21a).

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25 - 50	4	0	3.5	41.5
50 - 75	0	0	0	23
75 - 100	0	0	0	0.5
100 +	0	0	0	0
# Of plants measured :	99	16	115	183

Dotted line is placed below the height class containing the estimated height in 1992.

Table 21b. Height class distribution of living Saskatoon measured 4 years after planting
(Initially estimated as being 15 cm tall in 1992, all sites planted in 1991, measured in 1995)

Height class	Frequency distribution of Saskatoon (%)			
	15 cm			
	Cowley Bridge	Hay's	North Fork	Average
cm				
0 - 10	0	0	0	0
10 - 20	66.7	10	50	54
20 - 30	33.3	30	50	34
30 - 40	0	40	0	8
40 - 50	0	10	0	2
50 - 75	0	10	0	2
75 - 100	0	0	0	0
100 +	0	0	0	0
# Of plants measured :	36	10	4	50

Dotted line is placed below the height class containing the estimated height in 1992.

3.8.3 Competing vegetation

Although it is relatively shade tolerant, saskatoon prefers to grow in open sites (Watson et al. 1980). Four out of five sites were suffering from severe competing vegetation problems. The remaining site may also become overgrown in a year or two because the site vegetation is mainly comprised of seeded forage species. Heavy shading and choking out of the plants at these sites likely contributed to the low rates of survival and growth.

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Sampled seedlings showed moderate browsing damage, slightly higher than that recorded for aspen. Sixty nine percent showed past and/or present browsing damage, whereas 30% showed current year browsing (Table 22a). Seedlings estimated as being 45 cm tall in 1992 showed the highest incidence of browsing damage (97%) (Table 22b).

Saskatoon is listed as an important fall and early winter food of mule deer (Geist 1981). This species is able to tolerate moderate browsing, although hedging may occur if plants are heavily browsed (Watson et al. 1980). Shrubs tend to be browsed more than seedlings. Remaining patches of taller native saskatoon shrubs seen near the survey sites, (as with all palatable shrub species) were noted to be in very poor shape as a result of heavily utilization by deer.

In a study of woody plant establishment in northern Alberta, saskatoon received the highest rodent damage among the deciduous species tested, but it was able to re-grow quite well by re-sprouting from the roots (Fedkenheuer et al. 1980). In the sampled sites, generally minor damage attributed to rodents was noted. However, at one sample plot at Hay's site, there were signs of small mammal use and moderate small mammal damage was noted on Douglas fir, but no living

saskatoon or choke cherry plants were found. This raises the suspicion that rodent damage may have contributed to the lack of living saskatoon or choke cherry plants at this particular site.

3.8.5 Insect and disease

Insect and disease damage was moderate, but did not appear to seriously affect overall plant health. Some level of insect or disease damage was noted for 82% of the plants (Table 22a). Damage generally consisted of miscellaneous insect bites on leaves, but occasionally rolled leaves caused by leaf rollers or web worms were found. One plant showed symptoms of leaf blight, and a fungal leaf rust (possibly *Gymnosporangium clavariiforme* (Pers.) DC.) was noted at two sites. At the North Fork site (not included in survival calculations), the Northern tent caterpillar (*Malacosoma californicum pluviale*), was observed feeding in native stands of saskatoon and choke cherry below one study plot. Although their "tents" are unsightly, these defoliators usually cause little permanent damage to the tree (Ives and Wong 1988).

Table 22a. Incidence of damage to Saskatoon plants for all sites assessed in 1994 and 1995

Site name	Site #	1992 height (cm)	Site prep.	Year planted	Year sampled	# Of plants measured	% of total # of plants measured showing damage		
							Any browsing	Current year browsing	Insect/disease/ small mammal
Phil Maloff's	1	15	F-st	1991	1994	16	75	31	94
OCS mowed	2	15	F-sq	1991	1994	99	30	7	84
Peninsula	3	45	F-sq	1991	1994	183	97	43	80
Hay's	4	15	F-sq	1991	1995	10	50	30	100
Cowley Bridge	5	15	F-st	1991	1995	36	44	28	N/A
North Fork	6	15	none	1991	1995	4	0	0	0
Sites sampled in 1994 :						298	73	30	82
Sites sampled in 1995 :						50	42	30	84
All sites with Saskatoon, 1994 and 1995 combined :						348	69	30	82

WM : wood mulch; F-sq : fabric square; none : no site preparation

N/A : Not assessed at this site.

Table 22b. Incidence of damage to Saskatoon plants in two different initial height classes
(Estimated as 15 and 45 cm tall in 1992, all plants planted in 1991, sampled in 1994 & 1995)

Estimated height (cm), 1992	Year sampled	Site #'s	# Of sites in sample	# Of plants measured	% of total # of plants measured showing damage		
					Any browsing	Current year browsing	Insect/disease/ small mammal*
15	1994	1,2	2	115	37	10	85
15	1995	4,5,6	3	50	42	30	86
15	both 94 & 95	1,2,4,5,6	5	165	38	16	85
45	1994	3	1	183	97	43	80

* Cowley Bridge (site # 5, 36 plants), was not included in calculating insect/disease/small mammal damage, as this information was not recorded at this site.

3.8.6 Abiotic factors

Plants at the OC5 mowed site suffered mechanical damage caused by two years of haying. Many of the stems at this site were growing along the ground. Saskatoon is able to spread by stolons to form dense thickets (Moss 1933). This is what may be happening in response to the haying, which effectively chopped off the leaders.

Although saskatoon prefers to grow on moist soils, moisture may have been too abundant in some sites due to the recent summer weather conditions and the placement of snow fences at each site. At one site (Phil Malloff's) plantings survived better in areas where there were large gaps in the planting fences above. Below these gaps, vegetation was shorter and less dense, and contained a larger number of native species. Areas directly below the snow fences were overtopped by a lush growth of awnless brome grass. Other evidence of overabundant moisture includes snails seen on the vegetation, and a deep gully eroded underneath one of the planting strips caused by runoff.

3.9 Exclosure assessments

In 1994, planted species within two exclosures were sampled for height, width and damage factors. An equal sized plot was also sampled adjacent to each exclosure. Differences between the means for heights and widths of species occurring inside and outside the exclosure were compared using two sample t-tests (Appendix III).

No information on the location, size, date of construction of the exclosures, or the number and species of plants included within each were recorded in the APWSS wildlife habitat mitigation program final report data sheets (APWSS 1994). For this study, it was assumed that the exclosures were put up at the time of, or shortly after planting. However, because the height of the planted species in the planting polygons containing both exclosures were estimates recorded in 1992 rather than at the time of planting, it is possible that the exclosures were erected at this time. No records were found regarding weeding or other maintenance of these exclosure plantings.

3.10 Glass Property Exclosure

The Glass property deer exclosure is located in the upper west central section of the Glass property mitigation project area. It is situated within planting polygon 2674, east of a small enhanced wetland at this site (S.E. 21-7-29-4, vol.1, APWSS 1994). Planted species found inside and outside of the exclosure were Northwest poplar and common caragana. Bare root stock was planted, and no site preparation was used within the planting polygon containing the exclosure (APWSS 1994). The exclosure and adjacent sample site were approximately 20 m x 29 m in size.

Site vegetation is cultivated and seeded pasture, mostly dominated by awnless brome (*Bromus inermis* Leyss.), common dandelion (*Taraxacum officinale* Weber), and Canada thistle (*Cirsium arvense* (L.) Scop.) with a few large patches of crested wheat grass (*Agropyron pectiniforme* R. & S.) and Kentucky bluegrass (*Poa pratensis* L.). All of these species are invasive and highly competitive.

3.10.1 Northwest poplar

Northwest poplars assessed inside and outside the Glass property exclosure showed a survival rate of 93% and 81% respectively (Table 23a). This is much higher than that seen for Northwest poplar at the Glass' site (discussed in section 3.6), which showed a survival rate of only 9% (Table 14). This major difference in survival is likely due to differences in available moisture at the two locations. The Exclosure site is adjacent to an enhanced wetland. The 1991 range survey notes (included in the APWSS field notes) list the vegetation polygon containing the exclosure plantings as being a highly productive snow catch area, with a relatively fine textured soil. The Glass' site was located on a more exposed, south east facing, moderately sloping grassland with relatively coarse soil (APWSS 1994). Conditions at the Exclosure site were also suitable for vegetative reproduction because some suckering was noted both inside and outside the exclosure.

Poplars in the Glass property exclosure were significantly taller than those outside of the exclosure (Table 23a). Plants inside had an average height of approximately 121 cm, while those outside had an average height of 47 cm tall. Those inside showed an average increase of 31 to 61 cm, while those outside showed an average decrease of 13 to 43 cm from the 1992 estimated height range of 60 to 90 cm tall. A plant dieback may have occurred in 1989 or 1990 as indicated by the presence of many dead central leaders, and a large amount of branching in the following years (date estimated by counting annual growth scars on branches). Although the dieback may have been caused by climatic factors such as frost or drought, or insect or disease outbreaks, the significant difference in height inside and outside the exclosure suggest that deer browsing damage may have also played an important role in reducing plant heights. Widths were also significantly greater in plants measured inside than outside the exclosure (Table 23a).

Outside of the Glass property exclosure, all Northwest poplar showed some type of past or present browsing damage, with almost half showing current year damage (Table 23b). This is not surprising, as Balsam poplar is a preferred source of browse for mule deer in Alberta (Nietfield et al. 1985). Young trees and new growth are especially attractive to browsers (Watson et al. 1980).

All poplar inside and outside of the exclosure showed some level of insect or disease damage (Table 23b). Over 50% of the poplar plants outside the exclosure and 100% of those inside the exclosure were infested with aphids (likely *Chaitophorus populicola* Thomas.) and ants. The

extent of damage caused by the aphids did not appear to be high. A few poplar outside the enclosure were infected with orange leaf rust (likely *Melampsora occidentalis* Jacks.). Heavy infestations or infections of either of these organisms can result in premature defoliation, but neither are likely to kill the host tree (Ives and Wong 1988, Hiratsuka 1987).

3.10.2 Caragana

Caragana is a hardy, drought tolerant small tree or shrub native to southwestern Russia. This species is often cultivated as a hedge or windbreak in Alberta (Moss 1983). Survival of caragana was generally high both inside and outside the enclosure (78% and 87% respectively), with survival being slightly higher outside (Table 23a).

In 1994, the heights of plants within the enclosure were significantly higher than those outside, with an average of 108 cm inside, and 82 cm outside (Table 23a). Based on 1992 height of approximately 60 cm tall, caragana showed growth both inside and outside the enclosure. Those inside grew about 45 cm, and those outside about 12 cm. Plant widths were also significantly greater inside the enclosure (Table 23a). This suggests that deer browsing damage may also affect the growth of this species, but not to the extent of Northwest poplar.

The level of deer browsing damage on caragana was lower than that seen for poplar. Only 41% of the caragana plants sampled outside the enclosure were found to have some level of past and/or present deer browsing damage. None were noted as showing evidence of current year browsing damage (Table 23b). Although caragana is occasionally browsed by deer, poplar plants appear to be preferred.

Although almost all of the plants inside and outside the enclosure showed some indication of insect and disease damage, the level of damage was very mild, with the recorded damage sometimes affecting only a few leaves. Outside the enclosure, slightly higher levels of insect defoliation were noted, but the damage was still considered to be minimal. Large spiders and their webs were present on every single caragana plant, and this may have reduced the insect damage to some extent. Although caragana are susceptible to the caragana aphid *Acyrtosiphon caraganae* (Cholodkovsky), and severe infestations may cause premature loss of foliage (Ives and Wong 1988), both aphids and ants were rarely noted on caragana in this study. Holes were found on lower stems of three plants. It was not recorded whether these were caused by rodents or insect and/or disease.

Several of the plants appeared to have died back in the past, and plants with split and dead main stems were seen. Most caragana plants had produced many suckers.

Table 23a. Survival rate and average height and widths for Caragana and Northwest Poplar measured inside and outside of the Glass Property Enclosure in 1994
(Both species planted in 1987, original height recorded in 1992)

Species	Location of plot	Total # of plants in sample ^a	% Survival	Estimated height (cm), 1992	Average height (cm), 1994	Average width (cm), 1994	
						1	2
Caragana	Inside	36	78	60	108	91	70
	Outside	38	87	60	82	60	48
Northwest Poplar	Inside	15	93	60 - 90	121	89	67
	Outside	16	81	60 - 90	47	62	41

NOTE : Means for height and widths are significantly different inside and outside the enclosure for both Caragana and Northwest Poplar (Two sample t-test : significance level of 5%)

^a Based on total of living, dead, and void spots counted.

1 : Measured across widest point of plant; 2 : Measured across plant at a right angle to widest point measurement

Table 23b. Incidence of damage to Caragana and Northwest Poplar measured inside and outside of the Glass Property Enclosure, 1994

Species	Location of plot	# Of living plants, 1994	Any browsing damage (%)	Current year browsing (%)	Insect/disease/small mammal damage (%)
Caragana	Inside	28	0	0	100
	Outside	13	41	0	97
Northwest Poplar	Inside	14	0	0	100
	Outside	32	100	46	100

3.11 Stevick's Exclosure

Stevick's exclosure is found within polygon 2672, directly south of cell 2 of the riparian dike ponds at this site (N.W. 2-7-1-5, vol.3, APWSS 1994). This polygon was planted in summer, 1989. Planted species found inside and outside the exclosure were: aspen, poplar, willow, and choke cherry. Only poplar and willow were found both inside and outside of the exclosure. Buffalo-berry (*Shepherdia canadensis* (L.) Nutt.) and rose were also listed as being planted in this polygon but none were found. Four litre containerized stock was planted in this polygon, with no permanent site preparation (APWSS 1994). Plantings appeared to be clumped randomly rather than with a relatively predictable spacing as at the Glass property exclosure. As a result, the number of plants originally planted in the sample area could not be estimated, so survival rates for this site could not be calculated. The exclosure and the adjacent sample plot were approximately 23.5 m x 23.5 m in size.

Vegetation at the site is seeded pasture dominated by tall dense quack grass (*Agropyron repens* (L.) Beauv.), and awnless brome, as well as Kentucky bluegrass, common dandelion, black medic (*Medicago lupulina* L.) and many large patches of Canada thistle. This mixture of noxious weeds and highly invasive, moisture loving grasses appeared to be affecting the growth and survival of planted species through shading and competition. The only site preparation used for these plantings was manure (APWSS 1994). This may have contributed to the weed problem at the site by providing a source of agricultural weed seeds, as well as an enriched medium for their growth.

Numerous mounds, likely caused by pocket gophers (*Thomomys talpoides*), were present both inside and outside of the exclosure. These mounds were usually covered in Canada thistle. Mounding by pocket gophers often contributes to the spread of weeds by providing seed beds for them to colonize (Nietfeld and Roy 1993). Below and above-ground pocket gopher herbivory may also be one factor involved in the mortality of planted materials, especially in the heavily affected plot outside of the exclosure. In one study in northern Arizona, aspen release from pocket gopher (*Thomomys bottae*) herbivory on roots resulted in a rapid and significant increase in survival, vegetative reproduction, and tree growth rates (Cantor and Whitham 1989).

All species found within the exclosure showed growth, while those outside remained at or below the 1992 height (Table 24a). This difference may be attributed to deer browsing damage, but other variables including differing levels of pocket gopher herbivory may also be a factor. Plant widths recorded inside the exclosure were also greater than those outside for all species (Table 24a). The means for the height and widths of the two species found both inside and outside the exclosure (poplar and willow) were compared. Only poplar heights were found to be significantly higher inside than outside the exclosure. Small sample sizes may have contributed to this outcome (Appendix III).

3.11.1 Willow

Both height and widths were slightly larger inside than outside the exclosure, suggesting that some browsing damage was occurring. Outside the exclosure, 6 out of 7 willow plants showed both past and current year browsing damage (Table 24a).

Willows inside the exclosure only showed 11 cm growth from the originally recorded height of approximately 60 cm. The average height of willow inside the exclosure was slightly taller (14 cm) than the height of those outside (Table 24a). This may be the result of the severe insect

damage noted on willow both inside and outside of the exclosure. Almost all of the willow (91% inside and 100% outside) showed insect damage (Table 24b). In many cases, the apical leaves of willow were heavily eaten by insects, and several willow plants were noted to be almost completely defoliated. Several of the willows had died back in the past, as indicated by a dead main stem, and the new plant sprouting from the roots.

3.11.2 Poplar

Poplar showed a significant difference in height (57 cm) between those inside and those outside the exclosure (Table 24a). Those inside showed between 38 cm and 68 cm growth, whereas those outside remained within the range of the originally recorded height of 90 cm to 120 cm (Table 24a). Outside the exclosure, 87% of poplar showed past or present browsing, and 27% showed current year browsing damage. Small mammal damage was noted on the lower stems of only one tree. Some of the trees had died back and a dead main stem was present.

Almost all of the poplars showed some level of insect and/or disease damage. Folded leaves caused by leaf rollers were seen on several plants, along with miscellaneous insect bites and holes from defoliating insects. Aphids and ants, as seen on poplars at the Glass property exclosure, were also noted. Some leaves were mildly infected with a fungal leaf rust, and a few blackened leaves, possibly caused by a fungal leaf blight were also noted. One tall poplar outside the exclosure had a large blackened rotting patch on the side of the lower stem, possibly some form of canker caused by frost, or an infectious disease.

3.11.3 Aspen and Choke cherry

Only 4 aspen, and 3 choke cherry plants were found inside the exclosure, and none were found in the plot outside. On average, aspens inside the exclosure showed an increase in height of 59 cm (similar to poplar). Choke cherry plants showed much less growth, and were on average, only 2 cm taller than the original recorded height. All aspen and choke cherry plants showed some insect and/or disease damage. Some of the aspen plants had died back in the past, (as indicated by dead main stems), and were re-sprouting from the roots.

Table 24a. Average height and widths for species measured inside and outside of Stevick's Exclosure
(All species planted in 1989, and measured in 1994. Original heights recorded in 1992)

Species	Location of plot	Number of living plants, 1994	Estimated height (cm), 1992	Average height (cm), 1994	Average width (cm), 1994	
					1	2
Willow	Inside	11	60	71	26	19
	Outside	7	60	57	24	14
Poplar*	Inside	9	90 - 120	158	64	49
	Outside	15	90 - 120	100	53	40
Aspen	Inside	4	45	104	35	21
Choke Cherry	Inside	3	45	48	22	15

* Means for poplar height are significantly larger inside than outside the exclosure (two sample t-Test, significance level of 5%).

1 : Measured across widest point of plant; 2 : Measured across plant at a right angle to widest point measurement

Table 24b. Incidence of damage to species measured inside and outside of Stevick's Exclosure

Species	Location of plot	Number of living plants, 1994	Any browsing damage (%)	Current year browsing (%)	Insect/disease/small mammal damage (%)
Willow	Inside	11	0	0	91
	Outside	7	86	86	100
Poplar	Inside	9	0	0	89
	Outside	15	87	27	100
Aspen	Inside	4	0	0	100
Choke Cherry	Inside	3	0	0	100

4 CONCLUSIONS AND RECOMMENDATIONS

4.1 Survival

Average survival was 45% for all species combined, with the majority of individual species showing less than 50% survival.

Survival for rose appeared to be high, with a calculated survival rate of over 100%. Rose was regenerating naturally at most of the sites.

Aspen, choke cherry and saskatoon showed the next highest calculated survival rates, but these were slightly below 50%.

Douglas fir and Northwest poplar showed the lowest survival rates. Both were under 20%.

Aspen had much lower survival in sites sampled after two or three years as compared to those sampled in the year following planting.

4.2 Height growth

Height growth was poor for all species, with the majority of plants showing no height increase, or a decrease in height from the planting height or the height recorded in 1992. The decrease in height was often associated the dieback of the original seedling.

Choke cherry and saskatoon had the largest percentage of plants showing growth when compared to other species, but the majority of plants were still at or below the 1992 height.

Aspen and Douglas fir had a slightly smaller percentage of plants showing growth than choke cherry and saskatoon. For those that did demonstrate growth, the growth rates were well below those expected for these species under optimal conditions.

Rose and limber pine showed very little growth.

Northwest poplar showed no growth, and all plants were below initial 1992 heights.

Choke cherry and saskatoon seedlings from larger planting stock had a greater percentage of plants showing growth. They also reached taller height classes than did plants from smaller planting stock of the same species.

Heights of both Northwest poplar and caragana were significantly taller inside than outside the Glass property enclosure.

4.3 Factors affecting survival and height growth

In this study, competing site vegetation, browsing damage, and insect and disease damage were assessed. Competing site vegetation and deer browsing damage were found to be the two main factors affecting survival and height growth. Abiotic factors including climate and site conditions

were also found to be of importance. It should be noted that strong interactions occur among competition, herbivory and abiotic factors under natural conditions (Swank and Oechel 1991; Shabel and Peart 1994). As a result, no single factor can be regarded as causing the high mortality and poor height growth noted in this assessment. In order to assess the individual and combined effects of these three factors on the survival and growth of planted seedlings, experimental testing would be required.

4.3.1 Competing vegetation

Competing site vegetation appears to be an important factor affecting seedling growth and survival. Sites with tall thick vegetation generally showed lower survival rates and less growth than those with shorter or sparser vegetation.

Snow fences erected to increase soil moisture available to the seedlings, appeared to greatly encourage the spread and growth of weeds and agronomic grasses and legumes at planting sites where these invasive species were present.

Site preparations used to control site vegetation appeared to work reasonably well where vegetation was not very tall or dense to begin with. In sites with very short or sparse native vegetation, no site preparation was required. In extremely overgrown sites, none of the site preparations provided substantial benefits to the planted materials. Of the preparations used, fabric squares appeared to perform the best. Wood chips worked almost as well and were more aesthetically pleasing and "environmentally friendly", but washed or blew away on steeper slopes. Fabric strips were the least effective.

4.3.2 Browsing damage

Deer browsing damage also appears to play a large role in reducing seedling height and survival.

Northwest poplar showed the highest amount of browsing damage. Choke cherry, saskatoon, aspen, and Douglas fir all showed a moderate amount of damage. All of these species are considered to be preferred browse of mule deer, and were planted to provide additional food and cover habitat. Limber pine is not as palatable, and showed the least amount of damage. Rose browsing damage was obscured by mowing and cattle damage at the sampled sites.

Taller choke cherry and saskatoon seedlings appeared to be browsed slightly more than shorter plants of the same species. They also appeared to be more vigorous and better able to withstand, and likely outgrow this damage.

The significantly taller heights of Northwest poplar and caragana plants growing inside the Glass property deer enclosure, and significantly taller heights of poplar growing inside Stevick's deer enclosure suggest that deer browsing may be affecting seedling heights at these sites.

Small mammal damage does not currently appear to be a major problem.

4.3.3 Insect and disease

Insect and disease damage was present on almost all of the sampled plants but this type of damage did not appear to have a major effect on survival or health, and no treatments are currently

recommended. More detailed investigations in these areas are required, and may indicate problems not noted in this study.

4.3.4 Abiotic factors

Climatic conditions have a large influence on survival, and winter damage caused by chinook winds common to this region may have been a factor in the leader diebacks and stunted growth forms noted in this survey.

Site conditions including soil texture, pH, drainage, depth to water table, slope, and aspect, largely determine the distribution of plants under natural conditions. These factors are therefore expected to play a large role in determining whether planted seedlings will establish and continue to survive in the various sites.

4.4 Implications for the Wildlife Habitat Mitigation Planting Program

The expected level of mortality factored into the final required planting amounts was not stated in the *strategy or action plan* (Green and Eccles 1989, Nilson and Green 1989). However, in their recommendations for the Oldman River Dam reclamation program, Hardy Associates Ltd. (1986) stated that for shrub establishment, seedlings should be planted at 150% of the desired density to compensate for seedling mortality. For the species that were assessed in the sampled sites, the amount actually planted was on average less than 38% of the required planting amount (Table 25). This initial reduction is equivalent to 62% mortality. In addition to this, the average mortality rate for species in the sampled sites was approximately 55% (Table 2). If the survival rates seen in the selected plantings are indicative of the survival of those species planted throughout the mitigation land base, approximately 12% of the required amount of aspen, 20% of choke cherry, 12% of Douglas fir, 52% of rose, and 14% of the required amount of saskatoon are expected to be still alive (Table 25).

In order to ensure that habitat replacement goals set out by the strategy plan for wildlife habitat mitigation in the Oldman River Dam reservoir (Green and Eccles 1989) will be reached, supplemental planting may be necessary. The natural regeneration of shrubs on the mitigation land base may be contributing to the replacement of habitat. This contribution should be assessed before supplemental plantings are prescribed.

Table 25. Required and planted number of species found in sample sites, and probable survival of these species based on survival rates seen in this survey

Required species*	Number required September 1991*	Actual number delivered by July 1993*	% Of required amount actually planted	Probable number remaining**	% Of required amount expected to survive**
				19,200	12
Aspen	158,312	40,000	25	9,600	20
Choke cherry	48,063	20,000	42	5,200	12
Douglas fir	41,687	40,000	96	5,000	52
Rose	9,536	5,000	52	9,600	14
Saskatoon	70,390	20,000	28	48,600	15
Total:	327,988	125,000	38		

* Figures provided by Nilson, pers. comm. 1995. Required amounts quoted from September 10, 1991 memo received from the Delta Environmental Management Group Ltd. Northwest poplar is not included because only combined figures for poplar and willow were provided.

** Based on survival rates seen in sampled sites.

Growth rates were also found to be low due to competing vegetation and browsing pressure. Unless these factors are controlled, it is unlikely that the remaining seedlings at the mitigation sites assessed in this survey will survive and grow to eventually provide the food and cover habitat that they were intended to replace. If supplemental plantings are considered, steps must be taken to improve initial growth of the seedlings.

4.5 Recommendations

4.5.1 Plant and species selection

If rapid natural regeneration of shrubs used by deer for food, including saskatoon, choke cherry and rose is occurring on the mitigation land base as suggested by preliminary studies (Nilson, pers. comm. 1995), future plantings should concentrate on Aspen and Douglas fir, two tree species that are regenerating at much slower rates. The winter thermal cover provided by these species is especially lacking on the mitigation land base, and current plantings will not likely fill this requirement.

Observations made during this survey indicate that there is a shortage of patches of taller woody browse species used for both food and cover. Planting and protecting patches of saskatoon and choke cherry from browsing and competition to allow them to grow beyond 1.5 m tall would be beneficial even if natural regeneration is occurring.

Planting larger, faster growing seedlings, combined with some method of browsing control should increase the likelihood of seedlings growing beyond the reach of browsing deer after the first few years.

Limber pine did not appear to be competitive under the conditions at the planting sites, and further planting of this species is not recommended.

Rose appeared to be regenerating naturally at most of the sites, and further planting of this species does not appear to be warranted.

4.5.2 Planting site conditions

Reviewing daily temperature and precipitation records for this area for the time period between initial planting and sampling may shed some light on survival and damage noted at the various sites. This data may also indicate an optimal planting time frame, where chances of seedling survival will be increased.

In future plantings, site conditions (micro-climate, soil conditions, depth of water table, topography) should be carefully measured to better match species to specific sites. This will save money and time by ensuring that species are only planted in areas where they are reasonably adapted to grow, and are likely to survive when initial irrigation and weeding is discontinued.

4.5.3 Vegetation control

To increase the likelihood of success for future plantings, sites with dense or weedy vegetation should be avoided. If this is not possible, steps should be taken to control this problem prior to planting. Vegetation control can be accomplished through chemical or mechanical means. Although some sites in areas previously seeded with awnless brome and alfalfa were mowed before planting, these hay species grew back and eventually took over the site. One method that has been used successfully to control awnless brome grass and crested wheat grass is controlled burning of the site, combined with the application of glyphosphate herbicide to the rapid new growth of the introduced species. This allows the less invasive native species, initially suppressed by the burning, to recover at the site (Romo and Lawrence 1990). Re-seeding of native species at certain sites may also be required. Careful planning should be undertaken prior to removing any existing site vegetation, as soil erosion caused by wind or runoff may occur at susceptible sites. Any exposed soil is also susceptible to weed invasion. Removal of forage species and weedy vegetation in the vicinity of wetlands is not recommended as this tall growth provides nesting cover for dabbling ducks and habitat for other birds and mammals.

Vegetation control to reduce competition for light, moisture and nutrients is currently necessary at almost all of the sites, and is highly recommended for future plantings. Possible control measures would include: cutting of vegetation between plants using a "weed whipper"; spot treatments with a post-emergence herbicide designed for use around nursery stock; and manual weeding of planting holes. General treatment of sites with herbicides is not feasible because it would damage the planted seedlings. Although manual weed control is time consuming and expensive, in the long run it should produce better results, and be more time and cost efficient than replacing failed plantings.

Vegetation control is also recommended for future plantings as a preventative measure against possible girdling of planted seedlings by small mammals. Reducing dense vegetation decreases rodent habitat, and is currently the best method of control for small mammal damage.

To further reduce competition at future plantings, weed control site preparations can be used. Wood chips or fabric squares are recommended for this area. Wood chips were almost as effective and more natural looking, and less permanent than the black nylon fabric squares. Fabric squares are recommended on steeper slopes where wood chips may blow or wash away. Fabric strips are not recommended for use in future plantings, due to numerous problems noted in this assessment.

4.5.4 Browsing control

At the present time, some method of deer browsing control is required to allow heavily browsed seedlings to grow beyond their current stunted stage. This is also highly recommended for future plantings. Several studies have found various repellents to be effective in protecting native browse species and commercial plantings from white-tailed deer and mule deer browsing (Dietz and Tigner 1968; Conover 1984; Swihart and Conover 1990; Andelt et al. 1994). These and other currently available repellents should be investigated to find the most cost efficient and effective product for use in this area. Ideally these repellents need to be applied only once a year, until the seedlings grow taller than 1.5 m and out of the reach of browsing adult deer. Temporarily placing deer proof fences around selected plantings is another option (Byrne 1989). This is not recommended as they are generally expensive, unsightly, and require regular maintenance. The large number of relatively small planting units spread throughout the reservoir area would make this method impractical for use.

4.5.5 Insect and disease

Monthly inspections of all tree and shrub planting sites for disease and insect infestations are recommended in the site maintenance guidelines included in the APWSS final report field data sheet binders (APWSS 1994). As these guidelines were not provided by APWSS until the fall of 1995, these inspections were not carried out in 1994 or 1995. If planting sites were inspected for insect and disease damage prior to 1994, it would be beneficial to gather and review any data collected, and any records of insect or disease control measures used. This information would provide a better understanding of the influence of these factors on the survival and growth of seedlings planted in this area. Insect and disease outbreaks should be monitored in future plantings.

4.5.6 Irrigation and site maintenance

Maintenance guidelines for the tree and shrub plantings include weekly monitoring of soil moisture levels at sites with manually operated surface irrigation systems, and bi-monthly monitoring of soil moisture at sites with subsurface, gravity fed drip irrigation systems. This would allow tree and shrub seedlings to be watered as required, and indicate where adjustments to the drip systems were needed. Following these measures for an establishment period of at least three years after planting would ensure that adequate moisture levels are maintained over the entire depth of the root system throughout the growing season (APWSS 1994). Apart from brief notes in the "Maintenance data" section of 1992 and 1993 planting site information sheets stating that 2 waterings were applied at the time of planting, very little additional information on implemented watering schedules and site monitoring was included in the APWSS field notes (APWSS 1994). Only two of the sampled sites (Peninsula and Hay's), both planted in 1991, had comments indicating that weekly spring watering and bi-weekly fall watering occurred, and this information was only recorded in 1992, the year after planting (APWSS 1994). Any additional documentation of watering regimes, soil moisture monitoring data, and performance assessments of the irrigation systems at each site should be collected and reviewed. This information is crucial in determining whether sufficient moisture was provided in the critical first few years after planting, or whether insufficient irrigation may explain the poor survival seen at some of the sites.

Because the maintenance and irrigation guidelines were not received by Alberta Environmental Protection until the fall of 1995, the recommended irrigation schedules for each site were not known, and neither irrigation nor soil moisture monitoring were carried out in 1994 or 1995. According to the maintenance guidelines, (which recommend monitoring and irrigation for at least 3 years after planting), sites planted in 1992 would have required irrigation in 1994, and those planted in 1993, (including all aspen plantings sampled in this study) would have required irrigation in both 1994 and 1995. Because moisture conditions in the spring of 1994, and both the spring and summer of 1995 were high, additional irrigation may not have been necessary. However, weekly soil moisture level monitoring was not carried out to confirm this.

Maintenance guidelines also included general maintenance of irrigation system such as charging subsurface irrigation systems in the spring, and shutting down irrigation systems in mid September prior to the risk of heavy frost (APWSS 1995). Records of maintenance and any monitoring of irrigation systems to determine whether they were functioning according to specifications should also be collected and reviewed. This information is necessary to determine whether the subsurface drip irrigation systems provided adequate moisture to the planted seedlings. Information on

performance, durability and cost efficiency should be used to determine the best type of irrigation system or systems to be used in future plantings.

Both the plantings and the irrigation systems are costly investments. Regular maintenance and monitoring of the performance of irrigation systems should be undertaken to identify any problems in design or function requiring attention before planting failures occur. Soil moisture testing, and watering and maintenance schedules should be adhered to for at least three, and up to 5 years after planting if necessary. Detailed records should be kept, and any changes to watering regime and reasons for the change should be documented for future reference.

4.5.7 Summary comments

It is likely that much of the mortality and damage caused by competing vegetation, deer browsing, and insufficient irrigation could have been avoided if the plantings at each site were more carefully monitored, and the necessary care and maintenance were provided to sites after planting. For future planting projects of this nature, adequate funds should be allocated specifically for this purpose. Regular monitoring of sites should also have reduced additional damage to plantings from factors such as accidental haying or cattle grazing at the sites. For future plantings, sufficient initial watering, timely weeding, and the application of deer repellents, where necessary, should lead to better results.

The importance of keeping detailed and accurate records on the type and number of each species planted, planting patterns, spacing, and any changes made in the field, cannot be stressed enough. Incomplete baseline information on the plantings, and discrepancies between what was recorded, and what was actually found in the field, made it very difficult to estimate survival rates and growth with any certainty.

It would also be very useful to keep notes on planting variables that may have an effect on seedling survival and establishment. These variables include transport and handling of the planting stock, initial condition of the stock, specific planting procedures used, date, and general climatic conditions at the time of planting. Early monitoring and care of the plantings, and maintenance of the sites should also be recorded.

In future plantings, where eventual evaluation and monitoring are required, many problems can be avoided and statistically valid conclusions can be obtained by taking the time to set up permanent experimental monitoring plots using appropriate experimental design.

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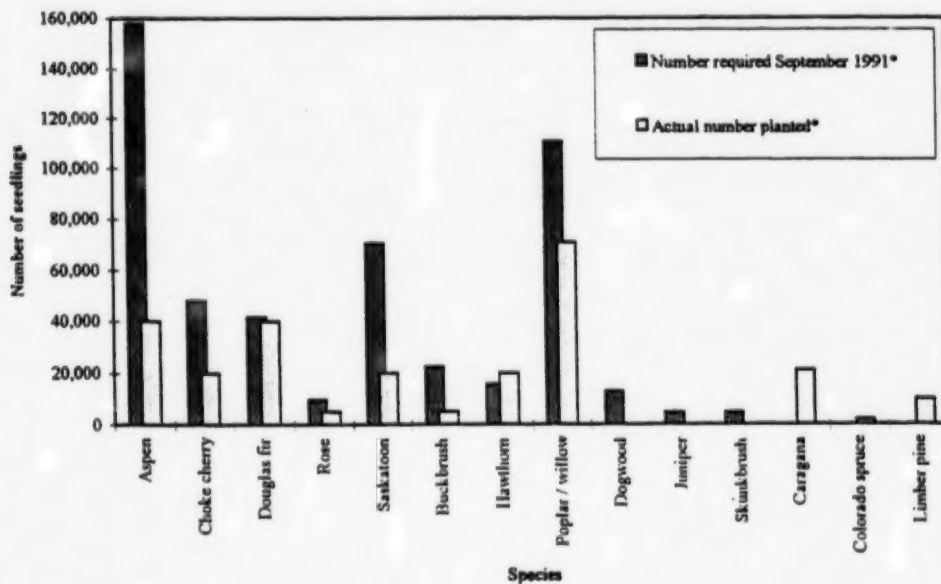
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APPENDIX I. Type and amount of seedlings required and planted as part of the Oldman River Dam Wildlife Habitat Mitigation Program

Required species*	Number required September 1989*	Number required September 1991*	Actual number delivered by July 1993*	Difference between planted and required amount
Aspen	31,662	158,312	40,000	-118,312
Choke cherry	9,613	48,063	20,000	-28,063
Douglas fir	8,337	41,687	40,000	-1,687
Rose	1,907	9,536	5,000	-4,536
Saskatoon	14,078	70,390	20,000	-50,390
Buckbrush	4,477	22,385	5,000	-17,385
Hawthorn	3,084	15,421	20,000	4,579
Poplar / willow	20,107	110,534	71,000	-39,534
Dogwood	2,599	12,995	0	-12,995
Juniper	947	4,736	0	-4,736
Skunkbrush	947	4,736	0	-4,736
Caragana	0	0	21,000	21,000
Colorado spruce	0	0	2,000	2,000
Limber pine	0	0	10,000	10,000
Total:	97,758	498,795	254,000	-244,795

* Figures provided by Nilson, pers. comm. 1995. Required amounts quoted from September 29, 1989 and September 10, 1991 memos received from the Delta Environmental Management Group Ltd.



*Figures provided by Nilson, pers. comm. 1995.

APPENDIX II. Sample data sheets

1994 Data sheets - continued

SITE PLAN



1994 Data sheets - continued

MITIGATION PLANTING SURVEY - ENCLOSURE DATA SHEET

Date _____

Biologist _____

Site I.D.

Species _____

Enclosed _____, Outside _____

Row # (s)

[illegible]

1995 Data sheets

MITIGATION PLANTING SURVEY - OVERALL SITE ASSESSMENT

Date:	Page #:	Biologist:
Site I.D.:	Polygon # ("a) :	Legal location:

Mitigation structure:	Snowfence	Exclosure	Irrigation system	Check dam
Planting site preparation:	Wood mulch	Fabric strip	Fabric square	Bare ground

Description of plantings / overall site:

Sampling method / description:

Photographs :

exp. #

Damage to planted species

APPENDIX III. Exclosure data t-Tests

t-Tests for the Glass Property Enclosure data : Northwest Poplar

Northwest Poplar Heights (cm)

NWP Inside	NWP Outside
120	40
115	35
140	50
140	60
110	50
120	30
135	50
110	30
135	40
100	55
110	60
130	50
110	60
115	

Heights (cm)

t-Test: Two-Sample Assuming Equal Variances

	NWP Inside	NWP Outside
Mean	120.7142857	46.92307692
Variance	168.6813187	118.9102564
Observations	14	13
Pooled Variance	144.7912088	
Hypothesized Mean Difference	0	
df	25	
t	15.92162312	
P(T<=t) one-tail	6.76739E-15	
t Critical one-tail	1.708140189	
P(T<=t) two-tail	1.35348E-14	
t Critical two-tail	2.05953711	

Alpha = 0.05

Difference is significant

Northwest Poplar Width # 1 (cm)

(measured at widest point)

NWP Inside	NWP Outside
100	35
80	10
90	60
100	90
90	80
70	45
80	70
60	40
95	75
100	50
100	65
100	90
100	90
85	

Width # 1 (cm)

t-Test: Two-Sample Assuming Unequal Variances

	NWP Inside	NWP Outside
Mean	89.28571429	61.53846154
Variance	164.8351646	605.7692308
Observations	14	13
Pearson Correlation	#N/A	
Pooled Variance	343.521978	
df	17.78230728	
t	3.63177797	
P(T<=t) one-tail	0.001030836	
t Critical one-tail	1.739606432	
P(T<=t) two-tail	0.002061672	
t Critical two-tail	2.109818524	

Alpha = 0.05

Difference is significant

Northwest Poplar Width # 2 (cm)

(measured at point opposite widest point)

NWP Inside	NWP Outside
35	25
55	5
85	50
70	60
80	60
70	30
60	60
50	20
90	20
80	50
50	55
80	50
90	50
40	

Width # 2 (cm)

t-Test: Two-Sample Assuming Equal Variances

	NWP Inside	NWP Outside
Mean	66.78571429	41.15384615
Variance	340.7967033	346.474359
Observations	14	13
Pooled Variance	343.521978	
Hypothesized Mean Difference	0	
df	25	
t	3.590515518	
P(T<=t) one-tail	0.000703024	
t Critical one-tail	1.708140189	
P(T<=t) two-tail	0.001406047	
t Critical two-tail	2.05953711	

Alpha = 0.05

Difference is significant

t-Tests for the Glass Property Enclosure data : Caragana

Caragana Heights (cm)

C - Inside	C - Outside
90	105
125	80
100	100
150	60
85	45
110	85
100	80
95	80
150	75
85	50
110	35
105	70
110	50
130	45
145	105
120	85
40	60
150	140
95	110
140	95
80	85
100	120
100	45
135	110
125	70
20	90
130	110
95	95
	100
	75
	80
	100

Heights (cm)

t-Test: Two-Sample Assuming Equal Variances

	C - Inside	C - Outside
Mean	107.8571429	81.71875
Variance	941.5343915	633.2409274
Observations	28	32
Pooled Variance	776.7568504	
Hypothesized Mean Difference	0	
df	58	
t	3.624221352	
P(T<=t) one-tail	0.000305853	
t Critical one-tail	1.671553491	
P(T<=t) two-tail	0.000611707	
t Critical two-tail	2.001715984	

Alpha = 0.05

Difference is significant

t-Tests for the Glass Property Enclosure data : Caragana - continued

Caragana Width # 1 (cm)

(measured at widest point)

C - Inside	C - Outside
80	80
130	55
110	85
120	80
90	35
90	80
70	55
80	90
120	40
80	40
95	20
90	70
85	40
120	25
120	50
110	60
20	30
135	100
80	60
120	70
70	55
90	55
85	35
120	85
90	80
10	75
95	70
70	110
	70
	35
	30
	80

Caragana Width # 2 (cm)

(measured at point opposite widest point)

C - Inside	C - Outside
80	70
90	40
70	45
100	50
80	25
90	70
70	40
85	60
95	20
70	35
85	15
72	55
45	20
90	20
90	50
105	40
10	20
85	80
80	45
100	70
55	40
70	25
55	30
110	85
55	80
10	60
85	70
35	70
	65
	25
	25
	75

Width # 1

t-Test: Two-Sample Assuming Equal Variances

	C - Inside	C - Outside
Mean	91.25	80.15625
Variance	865.9722222	528.2008048
Observations	28	32
Pooled Variance	685.4391164	
Hypothesized Mean Difference	0	
df	58	
t	4.589817599	
P(T<=t) one-tail	1.21487E-05	
t Critical one-tail	1.671553491	
P(T<=t) two-tail	2.42974E-05	
t Critical two-tail	2.001715984	

Alpha = 0.05

Difference is significant

Width # 2

t-Test: Two-Sample Assuming Equal Variances

	C - Inside	C - Outside
Mean	70.25	47.5
Variance	636.1944444	481.2903228
Observations	28	32
Pooled Variance	542.7112089	
Hypothesized Mean Difference	0	
df	58	
t	3.773789636	
P(T<=t) one-tail	0.000190034	
t Critical one-tail	1.671553491	
P(T<=t) two-tail	0.000380067	
t Critical two-tail	2.001715984	

Alpha = 0.05

Difference is significant

t-Tests for Stevick's Exclosure data : Willow

Willow Heights (cm)

W - Inside	W - Outside
45	50
80	120
50	45
85	45
110	25
55	70
85	45
60	
75	
85	
75	

Willow Width # 1 (cm)

(measured at widest point)

W - Inside	W - Outside
15	30
40	30
25	15
20	25
30	15
30	25
30	30
10	
25	
30	
30	

Willow Width # 2 (cm)

(measured at point opposite widest point)

W - Inside	W - Outside
10	20
20	10
10	10
20	10
25	10
30	10
20	25
10	
20	
15	
25	

Heights (cm)

t-Test: Two-Sample Assuming Unequal Variances

	W - Inside	W - Outside
Mean	71.3636364	57.1428571
Variance	355.454545	940.47619
Observations	11	7
Pearson Correlation	#N/A	
Pooled Variance	574.837662	
df	8.92353862	
t	1.10153311	
P(T<=t) one-tail	0.15134859	
t Critical one-tail	1.85954832	
P(T<=t) two-tail	0.30269918	
t Critical two-tail	2.30900563	

Alpha = 0.05

Difference is not significant

Width # 1 (cm)

t-Test: Two-Sample Assuming Equal Variances

	W - Inside	W - Outside
Mean	25.9090909	24.2857143
Variance	69.0909091	45.2380952
Observations	11	7
Pooled Variance	60.1461039	
Hypothesized Mean Differen	0	
df	16	
t	0.43293694	
P(T<=t) one-tail	0.33542001	
t Critical one-tail	1.74588422	
P(T<=t) two-tail	0.67084002	
t Critical two-tail	2.11990482	

Alpha = 0.05

Difference is not significant

Width # 2 (cm)

t-Test: Two-Sample Assuming Equal Variances

	W - Inside	W - Outside
Mean	18.6363636	13.5714286
Variance	45.4545455	39.2857143
Observations	11	7
Pooled Variance	43.1412338	
Hypothesized Mean Differen	0	
df	16	
t	1.59491195	
P(T<=t) one-tail	0.06514607	
t Critical one-tail	1.74588422	
P(T<=t) two-tail	0.13029215	
t Critical two-tail	2.11990482	

Alpha = 0.05

Difference is not significant

t-Tests for Stevick's Exclosure data : Poplar

Poplar Heights (cm)

P - Inside	P - Outside
185	85
145	125
100	100
215	130
110	95
110	125
180	45
130	80
245	130
	40
	205
	75
	80
	140
	40

Poplar Width # 1 (cm)

(measured at widest point)

P - Inside	P - Outside
75	55
55	85
30	45
90	70
80	50
40	70
100	35
55	45
70	75
	10
	120
	70
	80
	80
	15

Poplar Width # 2 (cm)

(measured at point opposite widest point)

P - Inside	P - Outside
55	50
50	65
30	40
60	50
60	40
35	55
60	20
40	35
50	65
	10
	40
	30
	30
	55
	10

Heights (cm)

t-Test: Two-Sample Assuming Equal Variances

	P - Inside	P - Outside
Mean	157.7777778	99.6666667
Variance	2619.444444	1989.52381
Observations	9	15
Pooled Variance	2205.858586	
Hypothesized Mean Difference	0	
df	22	
t	2.934483077	
P(T<=t) one-tail	0.003636176	
t Critical one-tail	1.717144187	
P(T<=t) two-tail	0.007272352	
t Critical two-tail	2.073875294	

Alpha = 0.05

Difference is significant

Width # 1 (cm)

t-Test: Two-Sample Assuming Equal Variances

	P - Inside	P - Outside
Mean	63.66666669	57.66666667
Variance	504.8611111	742.3809524
Observations	9	15
Pooled Variance	656.010101	
Hypothesized Mean Difference	0	
df	22	
t	0.576171162	
P(T<=t) one-tail	0.285173797	
t Critical one-tail	1.717144187	
P(T<=t) two-tail	0.570347595	
t Critical two-tail	2.073875294	

Alpha = 0.05

Difference is not significant

Width # 2 (cm)

t-Test: Two-Sample Assuming Equal Variances

	P - Inside	P - Outside
Mean	48.66666669	39.66666667
Variance	129.6611111	308.8095238
Observations	9	15
Pooled Variance	243.7373737	
Hypothesized Mean Difference	0	
df	22	
t	1.400992411	
P(T<=t) one-tail	0.087582455	
t Critical one-tail	1.717144187	
P(T<=t) two-tail	0.175164911	
t Critical two-tail	2.073875294	

Alpha = 0.05

Difference is not significant